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ON THE ILLUMINATION OF MARITIME COASTS.

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[*A Lecture delivered before the* FRANKLIN INSTITUTE, *November 19, 1886.*]

The beginnings of the illumination of maritime coasts are lost in the dim mists of antiquity. Nearly 3,000 years ago, the following lines were composed by the father of poetry:

> . . . . . and then he took the shield,
> Massive and broad, whose brightness streamed as far
> As the moon's rays. And as at sea the light
> Of beacon, blazing in some lonely spot
> By night, upon a mountain summit, shines
> To mariners, whom the tempest's force has driven
> Far from their friends across the fishy deep,
> So from that glorious buckler of the son
> Of Peleus, nobly wrought, a radiance streamed
> Into the sky. . . . . .
>
> (*Bryant's translation of the Iliad*, xix, 450–459.)

The description of the blaze of a beacon light in these verses is too definite to admit of the slightest doubt of the existence of such aids to navigation, even at this remote period.

About 300 B. C., the celebrated "Colossus of Rhodes," an immense bronze statue, spanning with its legs the harbor entrance, was constructed, and is supposed to have served as a light-house, until it was destroyed by an earthquake, eighty years later. About the same time, the equally far-famed "Pharos of Alexandria" was built by Sostratos of Cnidus. It is said that the fire, burning on the top of it, was visible at a distance of more than thirty miles, according to which the tower must have been above 500 feet in height. Pliny informs us that the cost of the structure amounted to a sum equal to about $2,000,000, and considering the much greater value of money at that early period, there can be no doubt that the dimensions of the building must have been exceedingly great. From the Pharos of Alexandria, in ancient times, the name was derived for the entire family of light-houses, which terminology has been handed down to the present day by the French language —the French word for light-house being "*phare*." Other less celebrated light-houses are mentioned by old writers as having existed at Ostia, at Ravenna, at Capio, and at various points on the British and French coasts.

The *object* of all *ancient* lights was simply to mark the entrances to harbors or rivers important for navigation, while the intermediate stretches of the coast were not lit up. The *modern* objects of the illumination of maritime coasts are more comprehensive: not only are the entrances of important rivers and harbors marked, but the entire line of the coast is lit up by a continuous chain of lights of different appearance, in order to enable the mariner approaching the coast at night to determine his whereabouts, and to shape his course towards his destination. The lights destined to give first warning of the vicinity of the coast-line, are the so-called "land fall-lights," or "primary coast-lights," lights of the most powerful degree of intensity, and placed at a very high elevation, so that their range of visibility is great, generally varying from about twenty to about twenty-five miles. The distance between two adjacent land fall-lights should always be smaller than the sum of the two ranges of visibility, so that in clear weather one of them must be sighted before the ship can get into danger. Their location should be on projecting points of the shore, so that the polygon formed by them encloses within its area as far as possible all outlying dangers to navigation.

Between the land fall-lights (or primary coast-lights, as they are termed in the United States,) are inserted secondary lights, for the purpose of filling gaps between them, that are too wide; again, for marking the entrances of rivers and harbors, and finally, for marking such outlying dangers to navigation as are not enclosed in the polygon formed by the land fall-lights. For this latter purpose, light-ships are frequently employed, the construction of towers on seaward points being always a difficult and costly undertaking.

Such are, in general outlines, the ruling modern principles of the illumination of maritime coasts, as they were laid down in a report to the French Commission of Lights, made by Admiral Rossel, in the year 1825. According to these principles, the light-house systems of the important maritime nations have been developed during the course of the present century to a most remarkable degree. At the commencement of it, the coasts of England, Ireland and Scotland were lit up by only forty lights, which number, eighty years later, had increased more than ten-fold—to about 460. Still more wonderful is the growth of the light-house system of the United States, which, from twenty-three lights in the year 1800, has advanced to about 650 in the year 1886.

In order to enable the mariner approaching the coast at night to determine his whereabouts on sighting the first light, each light must be furnished with a characteristic feature, by means of which it is recognized, by means of which its identity is established. Without, for the present, entering on the details of this subject, it may be mentioned that these various characteristic features, by means of which lights are distinguished from each other, are produced in three different ways, viz.:

(1.) By grouping; that is, by building two lights in close proximity to each other, far enough apart that at any distance they will appear separated; and sufficiently close, that they will always be recognized as belonging to each other.

(2.) By means of colors (red, blue and green light).

(3.) By means of giving the light a varying intensity, in such a way, that within a certain period of time it decreases from greatest brilliancy to entire darkness, and then again increases to greatest brilliancy.

This latter method is the one most frequently employed and it

is clear that the duration of the period within which the intensity of the light varies, affords an easy means of forming any number of different characteristics. We shall further on return to this subject, and then see in which way lights of varying intensity are produced.

This matter of "characterizing" lights is of the utmost importance—of an importance which may be said to increase in the same ratio as the number of lights marking the various maritime coasts increases. With the growing number of lights, the average distance between two adjacent ones is diminished, the danger of mistaking one of them for the other is correspondingly increased, and it is scarcely necessary to mention by what disastrous consequences to human life and property a mistake of that kind may, and very often has been, attended.

It is not required for the purposes above mentioned, that each light should possess a characteristic peculiarity exclusively its own, a characteristic which it shares with no other light, but it is merely necessary that one and the same characteristic should not repeat itself within too short a distance. How far two lights of the same characteristic should, at least, be distant from each other, in order to avoid the possibility of one of them being mistaken for the other, is a question which, according to local circumstances, may be decided differently. As a general rule, this question will resolve itself into the other one, of how far the mariner's reckoning under ordinary circumstances is apt to be astray; and again, as a general rule, it may be said that two lights of the same characteristic, that are eighty miles distant from each other, cannot be mistaken one for the other.

To return now to the example of a ship approaching the shore at night. Let us assume that at a distance of twenty miles from the shore the first land fall-light has been sighted and recognized by its characteristic; then the mariner can approximately determine his whereabouts, and accordingly shape his course to his destination say for instance towards the mouth of a river. In passing along the shore, he will successively sight other coast lights, the recognition of which will corroborate the correctness of his course. At a distance of say ten miles he will sight the lights marking the entrance of the river, and the course of the vessel will now be shaped according to these. When the entrance is passed, the channel, which now becomes narrow, is marked by "range lights." A

range consists of two lights built at some distance from each other, and located so that the straight line connecting the two indicates the direction of the channel, and in passing from one of these ranges into the other the ship can proceed up the river by night with the same safety as in day-time.*

Having given in the above the general outlines of the object of the illumination of maritime coasts, we now proceed to discuss the optical devices and appliances employed for it.

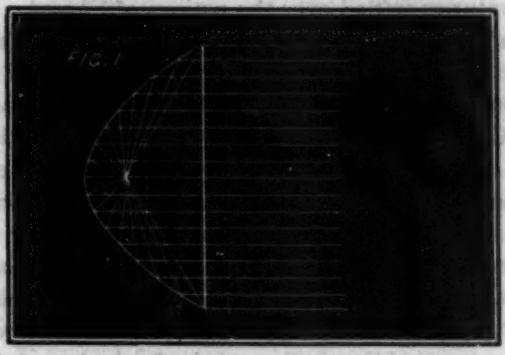
The ancient methods of light-house illumination are not known to us; there is, however, some reason to believe that in this respect, as in so many others, the ancients possessed knowledge and skill which were lost in the tremendous struggles preceding and following the downfall of Rome, and in the deep darkness which then for centuries settled over the nations of Europe.

Without entering into historical speculation on this subject, we will pass to the beginnings of the modern methods of light-house illumination. The first modern light-house of importance was the "Tour de Corduan" in the mouth of the Garonne, a French river emptying into the Bay of Biscay. This tower still exists and is perhaps the most magnificent structure of its kind on the face of the globe. It was finished in the year 1610, and for a long time was illuminated by burning billets of oak-wood in a *chauffer* on the top of the tower, later on by means of a coal-fire, but not until the year 1780 by means of lamps. The celebrated tower of Eddystone on the coast of Cornwall, until the beginning of this century, was lit up by means of twenty-four ordinary candles, unaided by any optical apparatus, and the tower on the Isle of May, also on the coast of Scotland, was illuminated by means of a coal-fire until the year 1816.

We perceive, from these examples, that the employment of the most primitive methods of light-house illumination reaches down to the very threshold of the present day, and, in considering these methods and their value, we find, above all, that they are extremely uneconomical. The rays of light emanating from a luminous point are distributed equally in all directions, and we may, therefore, properly speak of a globe of light being created by a lumi-

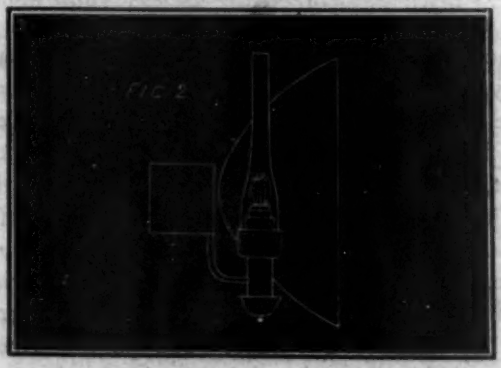
* The Delaware River from the Capes up to Philadelphia affords a remarkable example of a thorough and complete system of illumination as here described. E. A. G.

nous point. In our case, only a small part of the globe of light, created by the fire or the candles on the top of the tower, is actually utilized, namely, only that disc comprising the rays which lie immediately below the horizontal plane. Only these can reach the eye of the mariner, all others are useless; those above the horizontal plane being lost in space, and most of those below the horizontal plane striking the surface of the sea at points in the immediate surroundings of the tower, closer to it than a ship ever comes. In comparison to the entire amount of light produced, therefore, the amount of light actually utilized is very small. Hence, the intensity of the light in the useful direction is comparatively weak, and its range of visibility correspondingly small.

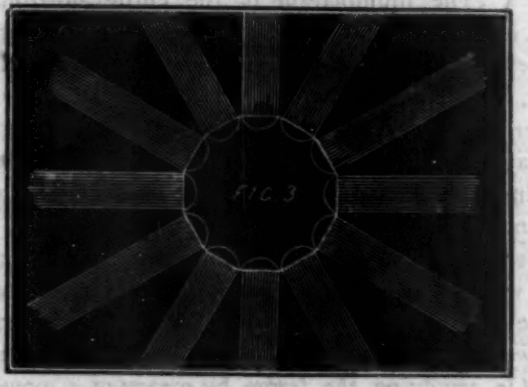


These considerations point directly to the requirements of an optical apparatus suitable for light-house purposes. Such an apparatus should be constructed so as to divert into the useful direction as many as possible of those rays, which without it would be lost. The greater the number of rays so diverted, the stronger will be the intensity of the light in the useful direction, and the greater, therefore, its range of visibility. A beginning in this respect was made on the "Tour de Corduan," mentioned before, by suspending an inverted cone over and into the fire burning on the top of the tower, in order to prevent the loss of light which escaped upwards. Later on, when candles and lamps commenced to be substituted for coal or wood fires, plane mirrors were placed behind them. From the plane mirrors, progress was made to spherical mirrors, and from these to parabolic reflectors. The

parabolic mirror possesses the property of reflecting in a bundle of parallel rays, the rays emanating from a luminous point situated in its focus, as shown in *Fig. 1.* Reflectors of this kind would, therefore, be eminently adapted for use on the aforementioned range



lights, the light of which need only be seen in one direction; that is, the direction of the channel. For this purpose, parabolic reflectors are still in use, and the arrangement of lamp and reflector is made as shown in *Fig. 2;* the flame of the lamp being situated



in the focus, the cylinder passing through an opening in the upper part of the reflector, and the oil-reservoir being situated behind it. In order to utilize the parabolic reflector for lights, which were required to be seen around the entire horizon, a number of them were arranged in a circle. Theoretically, each of these reflectors

would shed into space a bundle of parallel rays, and between these pencils of light there would remain dark angles, as shown in *Fig. 3*.

If this were the case in reality, then the object of illuminating the entire horizon would not have been attained, since, from a ship moving in one of the dark angles, the light would not be seen at all. In practice, however, the matter stands somewhat different; only the rays emanating from a luminous *point*, situated in the focus of the parabolic reflector, are reflected in a bundle of parallel rays. The flame of a lamp, however, is no luminous point; it has some extent, and those parts of it situated outside of the focus of the parabolic reflector will cause a divergency of the reflected rays, and, as far as this divergency occurs in the vicinity of the horizontal plane, it will serve to fill up the angles which otherwise would remain dark. An arrangement similar to the one shown in *Fig. 3* is still in use on light-ships. The parabolic reflectors are arranged in a circle, and enclosed by a circular lantern, through the centre of which the mast of the light-ship passes.

Although the angles between the bundles of rays are, as we have seen, filled with light, yet this light is, for obvious reasons, considerably weaker in intensity than the light in the bundles themselves. The illumination of the entire horizon, although complete, is, therefore, not a uniform one. In order to make it uniform, several tiers of parabolic reflectors were arranged one above the other, in such a way that the reflectors of an upper tier would stand over the gap between two reflectors of the next tier below. In this way, an almost entirely uniform illumination of the horizon was obtained, by a method, however, involving a great cost of maintenance, on account of the many lamps required.

In order to reduce this cost of maintenance, a smaller number of reflectors were arranged on a revolving triangular or square frame. Each side of this frame would shed into space a bundle of rays, and between these various bundles there would remain dark angles. On revolving the frame by means of a powerful clockwork, each point of the horizon, therefore, would be swept in regular periods alternately by light and by darkness. If, for instance, the frame were a square one making one entire revolution in four minutes, then the period of the light would be one minute; and from a ship approaching it, it would, in this space of

time, be seen decreasing from greatest brilliancy to entire darkness, and then increasing again to greatest brilliancy. Here, therefore, we have a method of producing the aforementioned lights of varying intensity, a method, however, which, has long since been supplanted by another one, that will be described later on. As a matter of general interest, it may be mentioned that a revolving light of this kind would be invisible at a distance of a few miles, were it not for the divergency of the rays caused by the extent of the flame. In explanation of this, let us suppose that there was no divergency of the rays; then each side of the revolving frame would shed into space a bundle of perfectly parallel rays, and the width of this bundle would be the same, at any distance from the light-house, as in the immediate vicinity of it, viz., only a few feet, or the width of the frame. At a distance of, say, ten miles from the light-house, this narrow streak of light would sweep by the eye of the observer with such an enormous rapidity that it would leave no impression on it; that is, the human eye would not be able to perceive it. In reality, however, we have, in the place of the bundle of parallel rays, a cone of light, on account of the divergency of the rays, and the width of this cone increases with the distance from the light-house. At a distance of ten miles, it is so wide that, notwithstanding the rapidity of its motion, it takes an appreciable time before it has passed the eye of the observer, a time amply sufficient for him to perceive it.

The desire to still further simplify the reflecting apparatus for light-houses has led to a very ingenious form of the parabolic reflector, by means of which the entire horizon is illuminated by a single lamp and a single reflector. The shape of this reflector is identical with the solid obtained by revolving a parabola around its parameter; that is, the straight line standing at right angles to its axis and passing through its focus. In *Fig. 4*, a central section of this reflector is given, which section appears in the form of two parabolas having one focus in common between them.

In this focus the flame of the lamp is placed, and it is clear that the rays in each central section must be reflected as shown; that is, they are uniformly reflected around the entire horizon.

Although the parabolic reflector certainly marks a very important progress in light-house illumination, yet it is subject to

serious defects. In the first place, a great amount of light is lost through absorption on the surface of the mirrors, even the best polished ones; again, a further considerable amount of light is lost through the divergency of the rays caused by the extent of the flame. As far as this divergency takes place in the horizontal plane, we have seen before that it is beneficial; as far, however, as it takes place outside of the horizontal plane, above it or below it, it simply means so much loss of light. Finally, the reflecting apparatus is objectionable on account of the great cost of maintenance involved. Only the apparatus shown in *Fig. 4*, the so-called "sideral light," is free from this defect, but it is applicable only for small lights.

These various shortcomings have been materially diminished by the introduction of the "dioptric" or "refracting" apparatus in the place of the "catoptric" or "reflecting" apparatus. The dioptric apparatus was invented by the Frenchman, Augustin Fresnel, about the year 1820, and its theory is founded on the well-known laws of refraction.

A ray of light, when it passes obliquely from one medium into another one, experiences a change of direction which is called "refraction." On passing from a rarer medium, into a denser medium, for instance air into water, the ray is bent *towards* a line perpendicular to the surface; vice-versa, on passing from a denser medium into a rarer one, the ray is bent *away* from a line perpendicular to the surface.

Now, let the line *R*, in *Fig. 5*, represent a ray emanating from

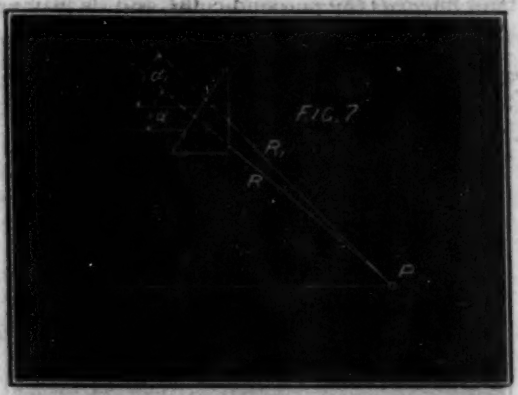
the luminous point P, and let a glass prism, the cross-section of which is a right-angled triangle, be interposed in the path of this ray, as shown in the sketch.

Then, on entering the prism (which is the denser medium) at m, the ray is bent *towards* the perpendicular, and on leaving the prism

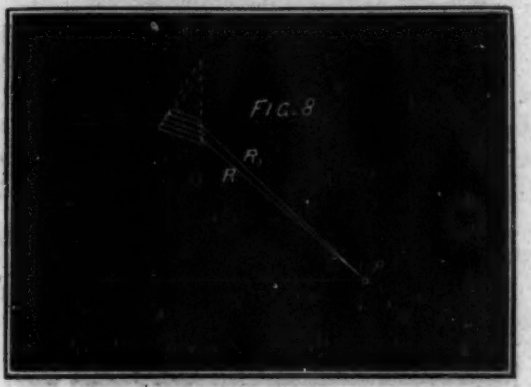
and re-entering the rarer medium, the air, at n, it will be refracted a second time, this time being bent away from the perpendicular. The sum of the two refractions, the angle a, is the entire change of direction experienced by the ray during its passage through the

prism. Other circumstances being equal, the size of this angle a is dependent on the size of the angle b, which is called the refracting angle of the prism; the greater the angle b, the greater will be the angle a; the smaller b, the smaller will be a. Within certain limits, therefore, we have it in our hands, by a proper choice

of the size of the angle b, to direct the ray in any direction we please, and we can, for instance, direct it into the horizontal plane, as shown in the sketch. In order to divert this single ray into the horizontal plane, the entire prism is not required, but merely that



portion of it through which the ray actually passes, and which is shown in *Fig. 6*. If this "element of a prism" fulfils the condition of its refracting angle, b being of the requisite size, then the ray will be refracted by it, into the horizontal plane. Another ray, R_1



emanating from the same luminous point, but striking the prism somewhat above the first ray, R, as shown in *Fig. 7*, will require a greater change of direction in order to be diverted into the horizontal plane, because evidently the angle a_1 is greater than the angle a.

The required greater change of direction can be brought about, as we have seen, by a greater refracting angle, and we can, therefore, divert this second ray into the horizontal plane, by placing on the top of our first "element of a prism" a second one, with a somewhat larger refracting angle, as shown in *Fig. 8*.

In a similar manner we can refract into the horizontal plane a third and a fourth ray by simply placing on the top of our two elements of prisms a third and a fourth one with still larger refracting angles (see *Fig. 9*), and we perceive that by doing this the originally straight line of the hypothenuse of our cross-section is changed into a polygon of as many sides as there are rays diverted into the horizontal plane.

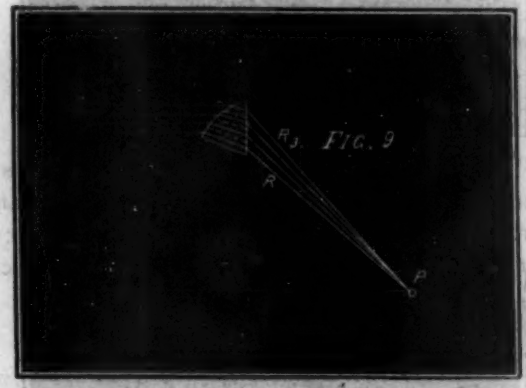
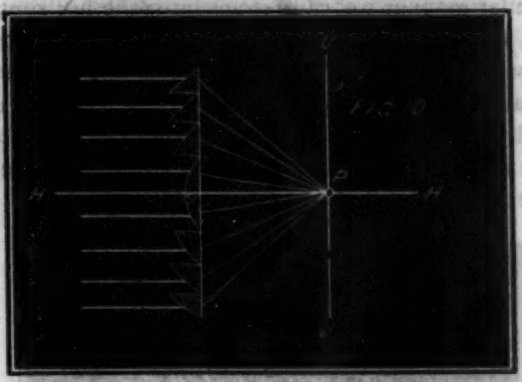


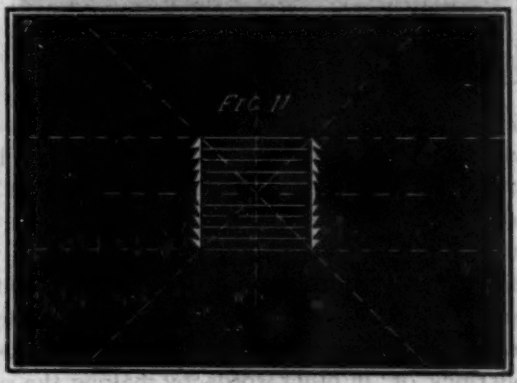
FIG. 9

In the sketch, four rays emanating from the luminous point *P*, are thus divided; we can, however, with the same facility, divert fifty, or 100 or 1,000 by simply making our elements of prisms thinner; or, in other words, by making the sides of our polygon more numerous and correspondingly smaller in length, and inasmuch as a single ray requires for its passage an element of prism of an inappreciable thickness only, we can divert *all* the rays that strike the rear side of the prism by making our elements of prisms inappreciably thick or; in other words, by making the sides of our polygon infinitely *small* in length and infinitely *great* in number, by which process the polygon is transformed into a continuous curve. The precise form of this curve can be computed, and when this is done and the glass is ground accurately according to it, then all the rays emanating from *P* and striking the rear side of the prism,

will be diverted into the horizontal plane. Below the first prism (see *Fig. 10*) we can, according to the same principles, arrange a second one, which will divert into the horizontal plane all the rays coming from *P* and striking *its* rear side; below this second one, a third one, and so on, down to the horizontal plane passing through



the point *P*. Below this horizontal plane, a similar series of prisms can be arranged, with this difference, that they will stand upside down, the refraction here having to take place the other way. In this manner, we obtain a cross-section (see *Fig. 10*) which has the

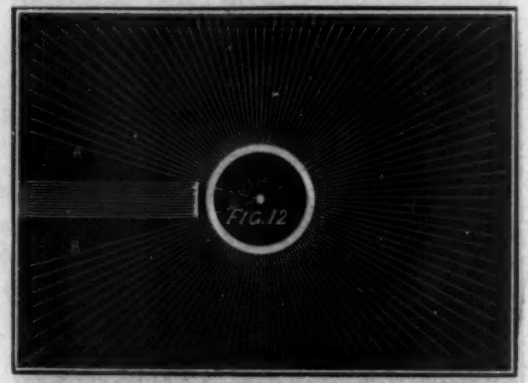


property of diverting into the horizontal plane by refraction, all the rays coming from a luminous point situated in its focus *P*.

This is the fundamental cross-section of Fresnel's apparatus, and from it we develop, by means of a few simple operations, the three main forms of it. The first of these operations consists in

revolving the fundamental cross-section around the vertical line *V V*, passing through its focus. The solid obtained in this way has the shape of a cylinder, composed of prismatic rings, put one on the top of the other. It is called the lenticular drum, and a vertical central section of it is shown in *Fig. 11*.

From what we know of the properties of the fundamental cross-section, it is clear that the lenticular drum must refract into the horizontal plane, all rays emanating from a flame situated in its focus and striking the interior smooth side of the drum. This refraction taking place uniformly all around, the entire horizon is thereby uniformly illuminated by what is termed a fixed light.



The second main form of Fresnel's apparatus is obtained by moving the fundamental cross-section in a horizontal position vertically upwards; the resulting solid consists of a number of prisms standing upright and side by side, the horizontal cross-section of this system of prisms being identical with the fundamental cross-section. If a system of prisms of this kind be placed in front of the lenticular drum, then the result clearly must be, that the rays leaving the drum radially and striking the rear smooth side of this appliance, are by it refracted into a bundle of parallel rays, as shown in *Fig. 12*.

The light which, without the system of prisms, would have covered the entire angle *A B*, is now condensed into the narrow space of the bundle, shown in the sketch. The light of the bundle will therefore be of greater intensity than the rest of the light, which the lenticular drum sheds radially around the horizon, and

at each side of the bundle there will be dark angles. If now the system of prisms be placed on a frame revolving around the fixed lenticular drum, then each point of the horizon will be successively swept by an intense flash of light preceded and followed by a short darkness; and the mariner approaching this light from afar will see during the greater part of the time the fixed light of the lenticular drum, varied at regular intervals by an intense flash preceded and followed by a short darkness. This second form of Fresnel's apparatus is termed the fixed light varied by flashes. Generally, there are several systems of prisms mounted on the revolving frame; for instance, three, as in *Fig. 13*.

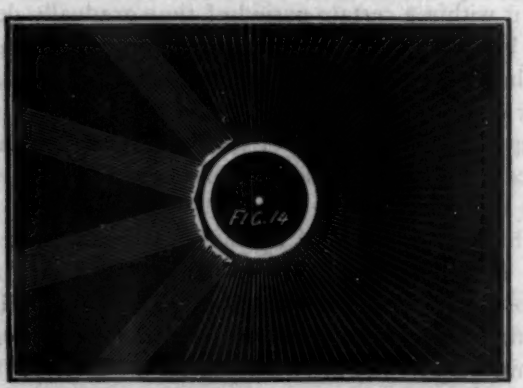
If the frame, in this case, were to make one entire revolution in three minutes, then the mariner approaching the light would see a flash every minute preceded and followed by a short darkness, and between each two flashes, he would see the fixed light of the lenticular drum.

It is not uncommon to arrange all the flashes close to each other on one side of the revolving frame, as shown in *Fig. 14*.

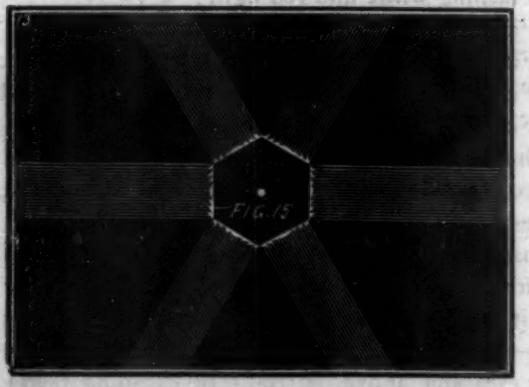
Here the mariner will see, during a part of the time, the fixed light of the lenticular drum, and then four consecutive flashes, separated from each other by short darkness. The arrangement of the fixed light varied by flashes can be further diversified by introducing colors; for instance, by making the flashes alternately red and white.

The third form of Fresnel's apparatus is developed by revolving

the fundamental cross-section around the line *H, H* (see *Fig. 10*), as an axis. The solid obtained in this way is a round disc, consisting of concentric prismatic rings, any central section of which must be identical with the fundamental section. It is evident, therefore, that this disc must refract in a bundle of parallel rays,



all rays coming from a luminous point, situated in its focus and striking the smooth rear side of the disc. This appliance, therefore, performs, by means of refraction, precisely what the parabolic mirror performs by means of reflection. In order to



utilize it for light-house purposes, the disc is trimmed into the shape of a rectangular panel and a number of these panels are then combined to form an optical apparatus, polygonal in form, each side of which will shed into space a bundle of parallel rays. In *Fig. 15*, the plan of a hexagonal apparatus of this kind is shown.

From each panel a bundle of rays emanates, and between the various bundles there remain dark angles. If, now, the entire apparatus be revolved by means of a clock-work, then each point of the horizon will be alternately swept by light and by darkness, and the mariner approaching the light will see it in this manner: he will perceive it within a certain period of time gradually decrease from greatest brilliancy to entire darkness, and then again increase to greatest brilliancy. If, for instance, the hexagonal apparatus shown in *Fig. 15* were to make one entire revolution in three minutes, then the changes in the intensity of the light described above would take place in the space of half a minute. This third main form of Fresnel's apparatus is called the flashing light.

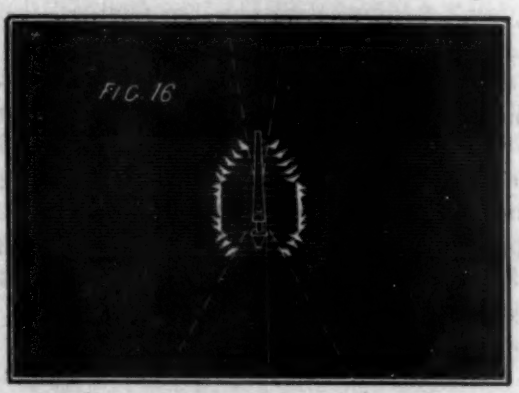
The three main forms of Fresnel's apparatus described above, the fixed light, the fixed light varied by flashes, and the flashing light, afford the possibility of producing an almost unlimited number of different characteristics. In the illumination of the coasts of the United States the three main forms are diversified as follows:

(1.) Fixed white light;
(2.) Fixed red light;
(3.) Flashing white light;
(4.) Flashing red light;
(5.) Flashing white and red light;
(6.) Fixed white light varied by white flashes;
(7.) Fixed white light varied by red flashes;
(8.) Fixed white light varied by red and white flashes.
(9.) Fixed red light varied by red flashes.

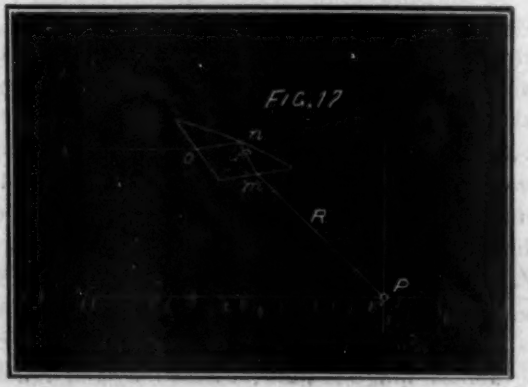
It is hardly necessary to add that these nine forms are further diversified by making the periods of time, within which the intensity varies, of different lengths.

An inspection of *Fig. 11* will show that, although the lenticular drum refracts into the horizontal plane, a great many rays, which without it would be lost, yet it by no means so refracts *all* the rays that are produced. A very considerable portion is still lost, partially by escaping above, partially by escaping below. A simple remedy would seem to suggest itself by heightening the lenticular drum; it would appear that the higher it is made, the fewer rays can escape above and below. But there is a limit to the application of this remedy; with the increasing height of the apparatus, the upper and lower rays will strike the smooth inside of it more and more

obliquely, thereby more and more increasing the loss of light by reflection to the inside of the drum. Practical experience has taught that the angle subtended by the height of the apparatus at its focus should not exceed 70°, and this therefore marks the limit to which the height of the lenticular drum can be profitably car-



ried. Fresnel himself has supplied a remedy for the above mentioned defect, which meets all demands. Above and below the lenticular drum, he arranged a series of prismatic rings which divert into the horizontal plane the rays striking them, not by refraction only, but by a combination of refraction and reflection.



A complete lenticular apparatus, furnished with this addition, is shown in *Fig. 16*. In the middle will be recognized the lenticular drum, while above it there are five, and below it there are three, of the above-described prismatic rings, the so-called "catadioptric rings," the operation of which is explained by *Fig. 17*.

The sketch shows, on an enlarged scale, the cross-section of one of the upper catadioptric rings. The ray enters at *m*, and is then refracted for the first time; it then strikes at *n* so obliquely, that it is totally reflected, and in leaving the prism at *o*, it is refracted a second time. The shape of the cross-section is carefully adjusted so that the two refractions and the one reflection will result in diverting the ray into the horizontal plane.

It is evident that from the apparatus, improved as shown in *Fig. 16*, only a small amount of light can escape without being turned to use, and Fresnel, therefore, through the addition of the catadioptric rings had raised his invention to a state of perfection, which it has been impossible to further improve upon.

The apparatus is employed in different sizes; for a small light it is only a few feet high; while for a first order coast light, with its flame of nearly five inches in diameter, it has a height of eight or nine feet and a maximum diameter of about six feet.

In the United States, the light is produced almost exclusively by mineral-oil lamps with argand burners. For powerful lights, several concentric wicks (as many as five) are used, with air spaces between them, the light produced by the inner wicks thus shining through the outer flames, by which expedient the intensity of the light is of course increased. For the larger lamps, ingenious contrivances have been constructed in order to secure the conveyance of a sufficient and constantly uniform supply of oil to the flame.

The range of visibility of lights is dependent on two circumstances, viz., their height above the sea and their intensity. We therefore speak of a geographical and of a luminous range. If the earth were not surrounded by an atmosphere, then the geographical range would be determined by the tangent drawn from the light to the circumference of our globe. The rays on their passage to the surface of the earth, however, successively enter denser and denser strata of air, and consequently experience a continuous refraction, as a result of which the path of the light changes from a straight line into a curve, the convexity of which is turned upwards. The geographical range is thus increased by the refractive action of the atmosphere. In connection with this, it should be mentioned that the light leaving the apparatus, in order to reach the eye of the mariner must be directed, not as we have hitherto assumed, into the horizontal plane, but slightly below it. The rays

emanating from the lenticular drum are therefore depressed by simply raising the most luminous portion of the flame somewhat above the focus, while the rays coming from the catadioptric rings are depressed by giving these latter a corresponding inclination.

The greatest range in our immediate vicinity is found at the lights on Navesink Heights; they are elevated 248 feet above the sea, and in clear weather are visible about twenty-two nautical miles. The lights of Absecon and Cape May are elevated 167 feet and are visible about nineteen miles. On the Pacific slope, much higher elevations are found; the light of Cape Mendocino, Cal., for instance is elevated 423 feet, and is visible twenty-eight miles. One of the highest light-house elevations in the world is that of a light at the Cape of Good Hope, which is 810 feet above the level of the sea, and can be seen at a distance of thirty-six miles.

A DEDUCTION FROM THE PRINCIPLE "THE MOMENT OF THE MOMENTUM" IN THE CASE OF TURBINES.

By Professor De Volson Wood.

Some time since I made the following transformation of the "moment of momentum," to see if it would shed any light upon the action of the water in a turbine. This principle being subject to independent proof, any deduction from it will be valid.

In the case of turbines, the moment of momentum of the water flowing through the wheel into the angular velocity of the wheel equals the rate of doing work; that is,

$$\frac{du}{dt} = M V \rho \omega \Big]^{\text{variable limit.}}_{\text{initial limit.}} \qquad (1)$$

in which

M = the mass of water flowing through the wheel in a unit of time;

V = the circumferential velocity of the water;

ρ = the radius-vector from the centre of the wheel to any point in the buckets;

ω = the constant angular velocity of the wheel;

t = the time considered;

u = the work done in the time t.

Since the work is done at a uniform rate, it is only necessary to consider the work done in a unit of time, and that unit may be one second, hence integrating, and making $t = 1$, we have

$$u = \omega \left[M V \rho \right]_{\text{initial lim.}}^{\text{gen. lim.}} \qquad (2)$$

for the work done per second. The quantity within the parenthesis is the "moment of the momentum," and between the limits the expression becomes — the work done by the water from its entrance into the wheel to any point (or arc) in the wheel equals the angular velocity of the wheel into the difference of the moment of the momentum of the water at entrance and at a distance ρ in the wheel.

Let

δ = the density of a cubic foot of water = $62{\cdot}5 \div 32{\cdot}2$;
Q = the cubic feet of water flowing past an arc $b\,a = \rho\,\theta$;
θ = the angular part of the wheel through which Q flows;
ρ = O a,
v_1 = the circumferential velocity, in reference to the earth, of the water passing $a\,b$;
v = the velocity of the water along the bucket at a, in reference to the bucket;
γ = the angle between a normal to the bucket at a, and the radius through a prolonged;

then

$$v_1 = v \cos \gamma,$$
$$M = \delta Q,$$
$$V = v_1 - \omega \rho$$
$$= v \cos \gamma - \omega \rho,$$

where $\omega\rho$ is the circumferential velocity of the wheel along the arc ab; and equation (2) becomes

$$u = \delta Q \omega \left[(v \cos\gamma - \omega\rho)\rho \right]_{\text{initial lim.}}^{\text{gen. lim.}} \qquad (3)$$

The moment of the momentum of the radial component of v will be zero, since the direction of its action will be through the centre of the wheel; hence the last expression is the total moment into the angular velocity.

Differentiating, observing that in the operation the inferior limits disappear, we have,

$$\frac{du}{\omega} = \delta Q \left[-2\omega\rho\, d\rho + v\cos\gamma\, d\rho - \rho v \sin\gamma\, d\gamma + \rho\cos\gamma\, dv \right].$$

Let x = the depth of the buckets at distance ρ from the centre;

$m = \delta x \rho\, d\theta\, d\rho$ = the mass of an elementary prism at a;

then

$$dQ = \delta x \rho \,.\, v\sin\gamma \,.\, \theta = \frac{m}{d\theta\, d\rho} \,.\, v\sin\gamma \,.\, \theta,$$

substituting which in the preceding, and differentiating again in reference to θ, gives us

$$\frac{d^2u}{\omega} = \rho\sin\gamma \,.\, m \left(-2\omega v + \frac{v^2\cos\gamma}{\rho} - v\sin\gamma\frac{d\gamma}{d\rho} + \cos\gamma\frac{dv}{d\rho} \right)$$

The d^2u is an element of the work, and an examination of the process by which it has been obtained shows, from the last differentiation, that it is the work of an elementary prism, whose mass is m, and from the first differentiation that it is the work produced by this mass on account of its change of position and direction of motion in reference to a change in the variables ρ, v and γ. In the last equation $\rho\sin\gamma$ is the perpendicular from the centre of the wheel, O, upon the normal to the bucket at a; and hence we infer that the quantities in the parenthesis multiplied by m are pressures normal to the bucket at a, due to the several changes in motion of the mass m with the wheel and along the bucket. Some of the terms in the parenthesis are readily interpreted, but the signification of others is not at once apparent, and although it may be a good exercise to determine their meaning from this standpoint, yet it is unnecessary to do so since it is virtually done in the solution of the problem of the turbine by Mr. Woodbridge, in the November number of this JOURNAL.

PRELIMINARY IDEAS ON THE CREMATION OF SEWER-GAS.

A METHOD FOR THE BETTER VENTILATION OF SEWERS, DRAINS, ETC.

BY N. WILEY THOMAS.

The term sewage is applied to all refuse and waste matter, which, if allowed to remain in or about our houses, in contact with air or without it, will produce disease and, in many cases, death.

The removal of this matter by methods originally intended to preclude any dangerous results was, and presumably is now, the office of a sewer system.

Sewer-gas is a comprehensive term, used to designate a greater or less number of gases and vapors, very complex in composition. This complexity of composition is not due to the great number of elements represented in the gas, but to the variety of ways in which these elements may combine with each other. The elements present in sewer-gas, and, indeed, certain of their compounds, are practically without any injurious effect. There are, however, products intermediate between these elementary bodies and the more ultimate products which are deleterious, and in the possibility of the formation of just these intermediate products lies the danger of sewer-gas. These are the results of the partial decomposition of the organic matter contained in sewage.

It is a well-known fact that all decomposition, as well as chemical combination, is greatly facilitated by heat. The absence of certain conditions is the real cause of the formation of the dangerous compounds. If sufficient oxygen with additional heat could be employed, these compounds, if formed at all, would exist only momentarily; they would immediately be converted into the more nearly ultimate or simple products. These latter are, indeed, obtained in every case, but the intermediate or dangerous products exist as such for a period of time sufficient to accomplish their deadly work. The methods now in use, we are convinced, do not succeed in accomplishing the object for which they have been proposed.

The problem of sanitary drainage has not as yet been solved. The sewer is, in the present state of civilization, a necessity; what remains to be done is to remove from it its dangerous nature. Sewer-gas, we believe, will be admitted to be the great dangerous product found in sewers. It is not our purpose to give a detailed account of different systems now in use, but simply, first, to remind the reader that the great majority of the so-called traps, about which the plumber and the builder make so many pretensions, are but a delusion and a snare. They might be more properly called death-traps. And, indeed, it must be said that the more complex they are the more dangerous do they become, since the readiness with which they get out of order increases with their complexity. In a word, then, the present methods are entirely superficial; they do not go to the root of the matter.

It is the purpose of this paper to briefly show how, by the cremation of sewer-gas, sewers may not only be ventilated, but, as a consequence, how this gas can also be destroyed:

The sewers, by means of suitable pipes, which should intercept near the roof, could be connected with a high chimney or stack; these pipes having passed through a furnace heated to redness before reaching the chimney, should then, by means of that chimney, be allowed to enter the atmosphere.

We believe it will be admitted that, at such a heat, the sewer-gas will be destroyed. Not only so, but this very heat with such draught would cause the current of gas to seek exit by means of this chimney. Should this draught be insufficient, blowers might be advantageously used to assist in the operation. By the destruction of the sewer-gas, we simply mean its conversion into simpler compounds, and we reaffirm our belief that at such temperature and in the presence of sufficient oxygen, this gas would be rendered harmless. The scheme is certainly theoretically possible; and in the hands of a competent engineer, could be made most effectual. Especially is it recommended to estates or large manufactories, where much can be done in this direction. The portion of the sewer used could be ventilated without assuming to ventilate the entire sewer. Another point; the boiler-furnace could be used to supply the heat. It is, at this time, merely intended to state the essential principles of the scheme. The main features are not original, but are based on the process of cremation

wherever carried out. The feasibility of the method could be tested without any considerable expense. Should it be found impracticable to place the pipes in the furnace, the connection could be made by simply allowing the gases of the sewer to mix with the gases of the furnace, and then associated with the latter to pass into the chimney. The advantages of the pneumatic system are more fully obtained than could be possibly hoped for without the presence of the heated gases. The scheme has the advantage of being extremely simple.

Any of our sewers now in use, whether those for surface drainage or those for the house and water-closet drainage could be so connected as to obtain the advantages of this system.

It is freely admitted that, at the present time, there is pressing need for the investigation of the question of sewage, and it is the principal intent of this paper to call attention to this subject, and to promote further investigation.

Girard College, November 3, 1886.

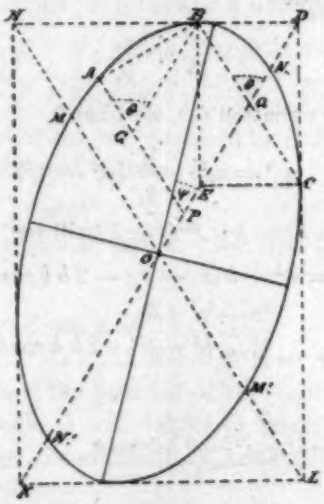
ATTRACTIVE FORCES IN GASES.—The founders of the kinetic theory in gases considered the gaseous molecules as solid, slightly deformable, elastic spheres, and this opinion is generally prevalent at the present day. Maxwell also considered the hypothesis that the molecules behave as centres of force, which repel one another in the inverse proportion of the fifth power of their distance. Boltzmann thinks it desirable to adopt various hypotheses, and especially to inquire whether a complete kinetic theory can be based upon attractive forces alone. He considers that the time integral can be employed with advantage so as to give a result, which will be both quantitatively and qualitatively in accordance with the laws of dissociation. The passage from dissociation to association differs from the condition of fluidity only in the circumstance that in the latter case aggregates are formed of many molecules which remain partly wavering as steam bubbles, partly adhering to the walls of the vessel or sinking through their weight to the bottom. The possibility of forming such aggregates through proper cooling may be readily deduced from the assumption of attracting molecular forces. The same forces which are active in the shocks of molecules, may also be applied to an explanation of dissociation and fluidity, whereas the hypothesis of repulsive forces during the approach of the gaseous molecules requires the assumption of entirely new forces for the explanation of those phenomena. As long as the collision of more than two molecules is absolutely prohibited, it can never be possible that two molecules can remain permanently together. Through the intervention of a third molecule, the living forces can be so diminished as to admit of a permanent union, and to introduce the various atomicities of molecules, the valency of atoms, etc.—*Annalen der Physik und Chemie, November 1, 1885.*

A NEWLY-DISCOVERED PROPERTY OF THE ELLIPSE.

BY L. D'AURIA.

In studying certain relations between physical quantities relatively to tidal rivers, the following problem of the ellipse occurred to the writer:

Given, of an ellipse, two tangents, D B, D C, at right angle with each other, the distances of their points of tangency, B, C, from their point of intersection D, and a third point A, determine the ellipse.



Being unable to find the solution of this problem in books of analytical geometry, the writer proceeded to solve it by the following method:

Let $A, B, C \ldots$ represent the desired ellipse, and upon the lines $B\,D$, $C\,D$ construct the rectangle $B\,D\,C\,E$. The diagonal $D\,E$ of such rectangle will determine the position of the transversal axis $N\,N'$ of the ellipse, and the other diagonal $B\,C$ will determine the inclination of the conjugate axis $M\,M'$, since $B\,C$ is bisected by $N\,N'$.

Now denote by (x_1, y_1) and (x_2, y_2) the co-ordinates of the points A and B, respectively; and by α, β the conjugate semi-axes $O\,N$, $O\,M$ of the ellipse. We have the following equations:

$$\alpha^2 y_1^2 + \beta^2 x_1^2 = \alpha^2 \beta^2; \quad \alpha^2 y_2^2 + \beta^2 x_2^2 = \alpha^2 \beta^2;$$

and can deduce

$$x_1^2 = x_2^2 - \frac{\alpha^2}{\beta^2}(y_1^2 - y_2^2). \tag{1}$$

Since the angular coefficients of the tangents $B\,D$, $C\,D$ are in the present case equal to *one*, because $B\,Q = Q\,C = Q\,D$; and since the analytical expression of such coefficient for the tangent $D\,B$ is

$$\frac{\beta^2 x_2}{\alpha^2 y_2},$$

we obtain the relation

$$\frac{\alpha^2}{\beta^2} = \frac{x_2}{y_2};$$

and substituting in equation (1), we have

$$x_1^2 = x_2^2 - \frac{x_2}{y_2}(y_1^2 - y_2^2). \tag{2}$$

Put $A\,B = l$; $A\,G = h$; $P\,Q = k$, will be

$$l^2 = h^2 + k(x_2 - x_1) - 2\,h\,k\cos\theta;$$

which gives

$$x_1 = x_2 + \frac{h^2 - l^2 - 2\,h\,k\cos\theta}{k}. \tag{3}$$

Put for brevity

$$\frac{h^2 - l^2 - 2\,h\,k\cos\theta}{k} = -m;$$

will be

$$x_1^2 = x_2^2 - 2\,m\,x_2 + m^2; \tag{4}$$

and comparing with equation (2), we have

$$2\,m\,y_2\,x_2 - m^2\,y_2 = y_1^2\,x_2 - x_2\,y_2^2,$$

or

$$x_2 = \frac{m^2\,y_2}{2\,m\,y_2 + y_2^2 - y_1^2}, \tag{5}$$

which determines the centre O of the ellipse.

Solving the equations

$$\alpha^2 y_2^2 + \beta^2 x_2^2 = \alpha^2 \beta^2, \quad \frac{\alpha^2}{\beta^2} = \frac{x_2}{y_2},$$

for α^2 and β^2 will be found

$$\alpha^2 = x_2 (x_2 + y_2); \tag{6}$$

$$\beta^2 = y_2 (y_2 + x_2). \tag{7}$$

Since the value of x_2 is given by equation (5), the values of α and β can be determined by equations (6) and (7); so that denoting by a, b, the principal semi-axes of the ellipse, the well known equations

$$\left.\begin{aligned}(a+b)^2 &= \alpha^2 + \beta^2 + 2\,\alpha\beta \sin\theta\,;\\ (a-b)^2 &= \alpha^2 + \beta^2 - 2\,\alpha\beta \sin\theta\,;\end{aligned}\right\} \tag{8}$$

will afford the determination of a and b since the angle θ is known. In fact, solving equations (9) for a and b will be found

$$a = \tfrac{1}{2}\left\{ \sqrt{\alpha^2 + \beta^2 + 2\,\alpha\beta \sin\theta} + \sqrt{\alpha^2 + \beta^2 - 2\,\alpha\beta \sin\theta} \right\}$$

$$b = \tfrac{1}{2}\left\{ \sqrt{\alpha^2 + \beta^2 + 2\,\alpha\beta \sin\theta} - \sqrt{\alpha^2 + \beta^2 - 2\,\alpha\beta \sin\theta} \right\}$$

Now let ψ represent the angle formed by $O\,D$ with the principal semi-axes a of the ellipse, will be

$$\alpha^2 = \frac{a^2 b^2}{a^2 \sin^2\psi + b^2 \cos^2\psi} = \frac{a^2 b^2}{\sin^2\psi\,(a^2 - b^2) + b^2},$$

hence

$$\sin\psi = \frac{b\sqrt{a^2 - \alpha^2}}{a\sqrt{a^2 - b^2}}. \tag{9}$$

Having determined the position of the centre of the ellipse by equation (5), the angle ψ will enable to describe the ellipse upon its principal axes by the well-known methods given in books of analytical geometry.

In the solution of the above problem, the relations (6) and (7) appeared to the writer to be of some importance. After little examination it became apparent that by summing them up, the following remarkable relation would result, viz.:

$$\alpha^2 + \beta^2 = (x_2 + y_2)^2,$$

and observing that

$$x_2 = O\,Q,\ y_2 = Q\,B = Q\,D,\ x_2 + y_2 = O\,D,$$

it follows

$$\sqrt{\overline{O\,M}^2 + \overline{O\,N}^2} = O\,D \tag{10}$$

This expresses a new property of the ellipse, namely:

If on the continuation of one of the conjugate semi-axes of an

ellipse a point is taken whose distance from the centre is equal to the square root of the sum of the squares of such semi-axes, the tangents thrown to the ellipse from such point will be at right angle with each other.

THE FUTURE WATER-SUPPLY OF PHILADELPHIA.

[*Abstract of the Report of* RUDOLPH HERING, *Engineer in charge of Surveys for the Future Water-Supply of the City of Philadelphia.*]

The final report of Rudolph Hering, engineer in charge of surveys for the future water-supply of the city of Philadelphia, was lately presented to the Water Committee of the City Councils. This report closes the three years' investigations, by the city, of all the available sources for the future water-supply of Philadelphia. It is a very voluminous document, and embodies what is regarded by scientific engineers as the most complete of any similar known work. The survey cost the city the aggregate sum of $80,000. Nearly 100 persons were engaged in the survey and sanitary investigation of the water-shed from which Philadelphia's future supply must come. Accompanying the report is a large number of plates, charts, and tables, showing the population of the surveyed territory, the topography of the country, the rain-fall of the various districts within a radius of 150 miles of Philadelphia, the location of proposed reservoirs, and a variety of other valuable detail information on the subject. The Councils had deferred consideration of certain propositions and of the subject of the water supply in general, during the summer months, awaiting the completion of this survey, and, with the information contained in the report now before them, it is expected that the subject will be taken up, and decided at an early date.

THE REPORT.

Mr. Hering says that the office corps has been engaged in computing the stream-flows of the Perkiomen, Tohickon and Neshaminy Creeks, in ascertaining the available storage in each of the respective valleys, in estimating its cost, and in arranging and compiling the tables, maps, and charts for the final report, and then continues:

In approaching the solution of the question as to where the city should go for better water when the Schuylkill River is no longer a fit source of supply, the definite conclusions arrived at in the previous reports were substantially as follows:

Two sources present themselves as excellent and superior to all others, viz., certain tributaries of the Delaware and Lehigh Rivers in the Blue Mountains. While either of these two rivers, or both, must be made use of at some distant date, other sources are at hand which, at a much smaller outlay, will furnish water of satisfactory quality and quantity for some time.

It was found that the Delaware River above Trenton, the Tohickon Creek, and the upper Perkiomen Creek, with its branches above Frederick (excepting the Macoby Creek), would all furnish a supply to which, as far as the quality of water is concerned, no reasonable objections can be made. The selection of the best among these near sources, however, depends upon the quantity of water available from each, either directly or by storage, in order to supply the city daily with 200,000,000 gallons, and upon the comparative cost of securing this quantity.

The latter two questions were not fully answered in the last report. They have now been finally determined. The upper Perkiomen Creek and its branches cannot be relied upon to furnish more than 89,000,000 gallons per day during a year of minimum rain-fall. An increase over this quantity would have to be obtained from the Blue Mountains. The Tohickon Creek could not be depended upon ordinarily to furnish more than 90,000,000 gallons per day, and in minimum years not more than 80,000,000 gallons. An increase beyond this amount would have to obtained from the Delaware River at Point Pleasant.

It is interesting to note that the Tohickon Creek gives the greatest average yield of water per square mile, and the Perkiomen Creek, above Green Lane, the next greatest, while the northeast branch of the Perkiomen gives the least. The computed average, minimum, daily yield in million-gallons from the water-sheds of the Tohickon and Perkiomen at Green Lane is: Tohickon, 86·5; Perkiomen at Green Lane, 60·1. Had the progress of the investigation made it certain that only stored water from the Perkiomen and neighboring water-sheds could be used for a future supply, it would have been necessary to enter into the question of storage and available quantity more fully. As, however, the economy of procuring the Delaware water at Point Pleasant, and the superior quality of the water in the Tohickon water-shed as compared with the Neshaminy, and particularly of

the lower Perkiomen, became evident, it was not considered essential to spend the time that would have been necessary for the comparison outlined above. The deductions which have been made and the results reached therefrom, were considered sufficiently close under the circumstances.

Estimates of cost for supplying 210,000,000 gallons daily, which was the amount to be provided for, and which can be conveyed to the city by an aqueduct twelve feet in diameter, show that the project contemplating the furnishing of 90,000,000 gallons of Tohickon water by gravity, and of pumping 120,000,000 from the Delaware River by water-power—in other words, the "Point Pleasant scheme"—is decidedly the most economical, and it is therefore the project recommended to the city in this report. The Delaware River below Point Pleasant, having a minimum flow at this point of some 1,500,000,000 gallons, would not be damaged by the withdrawal of 200,000,000 gallons.

Aqueducts.—But little needs to be added on this subject. Descriptions of the available routes to the different points where the water could be obtained have already been given, and the best of them have been carefully surveyed, mapped, and studied by means of profiles and estimates of cost. The aqueducts were estimated as having a diameter of twelve feet and a grade of one in 6,000. In building the same, it will be advantageous, in many instances, to deviate from a circular form, and other slight changes from the preliminary plans will be advisable. As the object of the present investigation was the solution of the broad question as to the best source for the future supply and the probable cost, it was not considered necessary to enter upon details regarding the construction of the aqueducts, when the cost was not materially affected thereby.

General Water-Sheds.—The surveys made to ascertain the suitability of certain water-sheds to furnish water of a good quality had also been completed before the present year, and have been reported upon. The physical features, viz., the contour and elevation of the ground, the untillable areas, those covered with timber and those under cultivation, also the towns, villages, roads, etc., had all been mapped.

The sanitary features, viz., the distribution and amount of population residing upon the water-shed, its principal occupations, death-rate, disposal of sewage, extent and character of mills, factories, slaughter-houses, cemeteries, etc., had also been ascertained and entered upon the maps or described. It might be repeated here that the large scale to which the surveys were plotted, viz.: 400 feet to one inch, the comparative accuracy of the survey and the amount of detail contained on the map, render them a valuable contribution to the survey of the state, inasmuch as they cover an area of 446 square miles in Bucks, Montgomery and Lehigh Counties.

The Aqueduct at Point Pleasant is 217 feet above tide-water. The minimum flow of the river was assumed at 1,500,000,000 gallons per day (see Table, p. 361, Report of 1885). Deducting the quantity to be raised into the aqueduct, there will remain enough water to supply power equivalent to 3,640 horse-power. Assuming that the motors employed will utilize eighty per cent. of the theoretical power, there will remain 2,912 actual horse-power. Adding for friction, etc., the lift of the pumps would be 137 feet. The pumping mains are thirty inches in diameter, and the distance to the aqueduct is 600 feet. The velocity in the same is assumed to be 312 feet per second. Computing the loss by friction of the pumps at three per cent., it is found that 117,463,000 gallons can be raised into the aqueduct every twenty-four hours, during the lowest stages of the river. As it is practicable to supply a much larger quantity of water during ordinary stages of the river, and at favorable times to pump into the lower storage reservoir of the Tohickon Valley, Mr. Hering assumes the available capacity of the Delaware River at 120,000,000 gallons per day, with a slight increase of cost.

General Conclusions.—In summing up the recommendations in the report, Mr. Hering says:

"It remains now briefly to recapitulate the final conclusions that have been arrived at from the examinations described above. In making these investigations, it has been taken for granted from

the outset that the water from any point in the Schuylkill River, and from any point in the Delaware River below Trenton, will not be of a sufficiently good quality to furnish a future supply for the city, although the fact has been admitted that at present the Delaware water at Lardner's Point, within the city limits, is not only fairly good, but is likely to remain so for some time.

In looking about for an improved supply, every practicable scheme was considered. No success could be expected from a supply by artesian- or driven-wells in this locality, nor would filtering or purifying the water of the Schuylkill or lower Delaware give permanent satisfaction. The only schemes worth investigating were those, which bring to the city the water of running streams in the Schuylkill, Delaware or Lehigh water-sheds.

It required but little thought to see that the water from the streams north of the Blue Mountains would be the best available in quality, not only now, but for an indefinite future, and that this region would therefore have to be the ultimate source of water-supply for Philadelphia, and probably also for other cities lying between the mountains and the seaboard.

To obtain an intelligent opinion on the cost of such a supply, surveys and examinations were made, which showed that, inasmuch as water of good quality can be secured at less expense from nearer localities, it is not advisable at once to go to the Blue Mountains.

The Ultimate Source of Supply.—In adopting a scheme for an earlier future, this ultimate source, however, should be considered, so that the aqueducts now constructed could be available for the final source of supply. The quality of water, which it was thought best to calculate for at present, was at least 200,000,000 gallons per day, or more than double the present consumption. The elevation at which the water should be delivered was fixed at about 170 feet above datum (the height of the present basin at Wentz's Farm and the proposed basin at Cambria), because it gives the most favorable distribution for the city.

The streams offering a good water-supply nearer than the Blue Mountains are the Perkiomen Creek, a tributary of the Schuylkill River; the Tohickon and Neshaminy Creeks, tributaries of the

Delaware River; and the Delaware River itself above Trenton. In point of quality the water of the latter has been found to be the best; that of the upper Perkiomen and Tohickon Creeks comes next in quality; and that of the Neshaminy and lower Perkiomen Creeks is least good.

The Most Economical Scheme.—An estimate of the cost of obtaining Delaware water alone, indicates that above Lardner's Point, the most economical scheme is to bring it from Point Pleasant, because the river has quite a descent near this place, which materially reduces the height of pumping as compared with points lower down the river, such as Lumberville, New Hope and Yardleyville. Another advantage gained by this sudden descent is the water-power which can be developed to furnish a daily supply of 120,000,000 gallons during the dry season.

The cost of the aqueduct, pumping plant, and capitalized cost of pumping amounts to $19,622,543, if 210,000,000 gallons of water daily are pumped by steam, and to $15,475,262, if only 120,000,000 gallons are pumped by water, and the remainder by steam.

Purely gravity supplies, without pumping, can be obtained either from the Perkiomen Creek or from the Tohickon and Neshaminy Creeks combined. The latter project cannot be made to furnish a daily supply of over 156,000,000 gallons in years of minimum rainfalls. While the water furnished by the Tohickon and upper Perkiomen Creeks is good, that which is taken from the Neshaminy and lower Perkiomen, as already stated, will be of much inferior quality. Neither of these purely gravity schemes would, therefore, be quite satisfactory.

The cost of procuring a supply from the Perkiomen Creek is $13,674,493, and from the Tohickon and Neshaminy Creeks together, $13,846,662.

Finally, a combined gravity and pumping scheme is possible, by procuring water from the Tohickon Creek and from the Delaware River at Point Pleasant. The former can furnish on the average between 90,000,000 and 100,000,000 gallons per day by gravity; in minimum years only 80,000,000 gallons can be depended upon.

The Delaware River, as we have seen, can furnish 120,000,000 gallons by water-power. Both the Tohickon and Delaware waters

have been found not only to be of good quality, but much better than the waters of the Neshaminy, and particularly of the lower Perkiomen Creek.

The cost of this scheme is $12,695,941, if the water-power is utilized, and $17,717,025, if steam-power is used.

It is, therefore, clear that the best and most economical project to supply the city of Philadelphia with water is to bring to it the Tohickon water by gravity, and to pump from the Delaware River at Point Pleasant by water-power.

In order to perceive the relative values of the different schemes with still more distinctness, I have made three estimates, one for completely filling the aqueduct, one for furnishing 150,000,000 gallons, and one for only 90,000,000 gallons per day.

To supply the latter quantity of water from the Perkiomen Creek will require an expenditure of $10,495,000. In bringing 90,000,000 gallons daily from the Delaware water-shed, it is found that the Neshaminy Creek alone could furnish this amount, except during years of minimum rain-fall, at a total cost of $7,875,000. The Tohickon Creek alone, could furnish a quantity up to 90,000,000 gallons, except during very dry years, at a cost of $10,008,000. If the Delaware water at Point Pleasant is used, the cost for 90,000,000 gallons will be $12,775,000, if pumped by steam, and $9,673,000, if pumped by water-power. At Lardner's Point, the cost will be $7,064,000.

Therefore, to supply the city daily with 90,000,000 gallons of water, which is the present consumption, the cheapest project is to pump the Delaware water at Lardner's Point; the next is the Neshaminy, and the third is to pump Delaware water at Point Pleasant.

To increase the supply to 150,000,000 gallons will require a total expenditure of about $12,139,000, if the Perkiomen water only is used, and a total expenditure of about $17,635,000, if no water is taken from below Green Lane and the deficiency supplied from the eastern affluents of the Lehigh River above the Lehigh Gap.

On the Delaware areas the water stored from the Neshaminy and Tohickon Creeks together, could furnish an amount up to 156,000,000 gallons, at a cost of $13,846,652. If, instead of using he Neshaminy water, Delaware water is pumped at Point Pleasant, he cost will be $14,275,000 if steam, and $11,215,000 if water-

power is employed. To supply Delaware water only will cost, if pumped by steam at Point Pleasant, $16,355,000, and at Lardner's Point, $10,415,000.

For supplying 150,000,000 gallons daily, therefore, from beyond Lardner's Point, the project contemplating the use of both the Tohickon and Delaware water at Point Pleasant, pumping the latter by water-power, is the least expensive one.

Finally, to increase the supply to 210,000,000 gallons, the Point Pleasant scheme, as already stated, is again the most economical one, besides furnishing water of decidedly the best quality.

It, therefore, appears with sufficient clearness, I think, that whenever good water can no longer be obtained from Lardner's Point by the pumps, which it may be considered advisable to place at this point, the city should build an aqueduct to Point Pleasant, pump Delaware water by water-power, and supplement the quantity as it may become necessary, by storing the water from Tohickon Creek, first in the lower, and then in the upper, reservoir.

After the aqueduct is taxed to its full capacity, at which time it will probably be necessary to go to the Blue Mountains for an increased supply, another aqueduct will have to be built. It is premature, I think, to say definitely, at present, whether this second aqueduct, extending to the Blue Mountains, should go by way of the Delaware or Lehigh Rivers. If the South Mountain region should preserve its present character, there can be no doubt that it should extend by way of the Perkiomen Valley, and, after receiving the South Mountain water at Green Lane, follow up the Lehigh River.

The cost of this scheme, which is now relatively greater than that of others, would then probably be less. Later, the Point Pleasant aqueduct could also be carried to the mountains whenever the quality of the water, owing to the pollution from the Lehigh River, became objectionable, and its extension would then most economically be to the Delaware Water Gap.

It will be better to build two separate aqueducts in this way, than only one, with double the capacity, because, in the latter case, the risk from accident becomes greater. New York, Boston, Washington and Paris each have two; London has even more.

When the above-mentioned aqueducts shall be built, the city of Philadelphia will be supplied with the best water obtainable in Eastern Pennsylvania.

REPORT OF A SPECIAL COMMITTEE OF THE FRANKLIN INSTITUTE TO FORMULATE A PLAN FOR A STATE WEATHER SERVICE.

[*Presented at the Stated Meeting, held Wednesday, December 15, 1886.*]

At a meeting of the Special Committee to Formulate a Plan for a State Weather Service, held Wednesday, December 15, 1886, the following report was adopted, and ordered to be reported to the next monthly meeting of the INSTITUTE.

W. P. TATHAM, *Chairman*,

LORIN BLODGET, WM. H. WAHL,
M. B. SNYDER, ALEX. E. OUTERBRIDGE, JR.

THE SUB-COMMITTEE, appointed to consider the advisability of establishing a "State Weather Service" for Pennsylvania, under the auspices of the FRANKLIN INSTITUTE, and in conjunction with the United States Government Meteorological Bureau in Washington, begs leave to offer the following report.

REPORT.

Experience has proved that the practical benefits to be derived from the daily forecasts of storms, cold-waves, etc., are greatly restricted, especially in the agricultural districts, by the want of sufficient facilities for disseminating the official information promptly. Farmers, who are especially interested in these forecasts, are usually so located that the reports do not reach them in time to be available as predictions, and they are therefore of little value to this class of the community. In order to overcome this deficiency, the experiment has been tried of establishing, in several of the Western and Southern States, an auxiliary "State Weather Service," with volunteer observers located at available points working under a chief, residing at some central locality, who in turn is in daily telegraphic communication with the Government Bureau in Washington. By the aid of this organization, it is found that the weather forecasts may be much more rapidly and widely disseminated than has heretofore been practicable. The State Services already established, have proved of great value

to the citizens, and have afforded material aid to the Meteorological Bureau, in its efforts to extend its usefulness. It is at the request of the officers of this Bureau, that the FRANKLIN INSTITUTE is considering the advisability of fostering the establishment of a similar service for Pennsylvania.

The Chief Signal Officer offers to aid the work, by furnishing all blank forms, upon which the reports are written, by supplying a competent instructor, and an inspector, who will visit the stations, compare and correct the instruments, collate the reports, etc., etc.

It appears, from the statements of the officers of the Meteorological Bureau, that the State Services already established, have proved invaluable to the communities in which they are placed; and this committee is of the opinion, that a similar service would prove equally valuable in Pennsylvania, and that it is a proper subject for the careful consideration of the FRANKLIN INSTITUTE.

By means of the efficient "Railway Bulletin Service," now in operation by the different railroad companies in this state, such a system is both possible and practicable, at a very small expense. By these companies, the weather indications of the Signal Service, are daily posted at over 300 stations well located for points of distribution.

By the "Flag Weather Signals," which can be displayed at these centres, and repeated or duplicated at proper distance from each other, the entire state can soon be covered with symbols, and the indications or warnings given to every locality participating in the work.

The value of such information is sufficient, to induce the belief, that if a system were properly organized, the people would very generally aid in these displays by volunteering their services.

While the stations of the Signal Service may be numerous enough for storm and frost-warnings and general weather predictions, they are not sufficient to determine the climatic conditions of our state sufficiently for the best scientific and practical results.

They are mere outposts for general work, so far apart that numberless meteorological phenomena occur, that, being unrecorded, are lost for comparison and study.

The value of systematic and continuous records of atmospheric changes cannot be over-estimated. There is not an industry in the country that could not be benefited by them.

For this purpose, a thorough system of taking and recording observations should be organized in every county. No doubt, with proper encouragement, a sufficient number of volunteers could be found for this work, and, in a short time, such an array of climatic data might be collected, that valuable and comprehensive information might be given, concerning the meteorological condition of any part of the state.

As above remarked, several of the states have already experienced and recognized the practical benefits to be derived from a "State Weather Service," and have appropriated money to properly furnish the stations with the necessary Government standard instruments, for measuring the pressure, temperature, humidity, rain-fall, wind, etc.

This should be done by the state of Pennsylvania, as the benefits would be general.

An appropriation of $3,000 will properly equip one station in every county, and furnish means for the monthly publication of a *Weather Review*, containing the tabulated reports of the observations.

After the stations are once established, the cost of maintaining a continuous service will be slight.

The following is a price-list of standard instruments, as published by the Signal Service:

Barometer,		$30 00
Thermometers	Dry bulb,	3 00
	Wet bulb,	3 00
	Maximum,	5 00
	Minimum,	4 00
Rain-gauge,		2 50
Instrument Shelter,		5 00

For the reasons herein stated, we suggest:—

That the FRANKLIN INSTITUTE at once organize a "State Weather Service" for Pennsylvania, having for its object the collection and collation of climatic data and phenomena, and the dissemination of the weather-forecasts, storm- and frost-warnings of the Signal Service.

That the work of taking observations, disseminating forecasts, warnings, etc., be accomplished by volunteer service.

That the co-operation of railroad companies, telegraph companies, telephone companies, newspapers, and others, who can materially aid in the dissemination of information, be solicited.

That the offer of the Chief Signal Officer of the Army, to furnish a member of the Signal Corps to assist in the work, be accepted.

That an effort be made to secure an appropriation of $3,000 from the state, for the purchase of instruments and for the publication of the observations in a tabulated form.

That all institutions of learning throughout the state, be solicited to take an active interest in the collection of meteorological data and the study of the science, for practical application to the various pursuits of life.

That at least one observer be secured in every county of the state, ten of whom should take and record barometric readings.

That copies of all meteorological data relating to the state be secured and placed on file in the Central Office.

That immediate action be taken to secure observers and display-men, so that the work may be commenced, if possible, on January 1, 1887.

That, if all the work suggested, cannot be at once carried out, such portions as can be done without expense, be started as soon as practicable.

That the management of this Service be placed in charge of a committee, appointed by the INSTITUTE, with power to regulate the service according to requirements.

AT THE STATED MEETING of the FRANKLIN INSTITUTE of the State of Pennsylvania for the Promotion of the Mechanic Arts, held Wednesday, December 15, 1886, the foregoing report was adopted and the Committee was continued, with instructions to carry into effect the plans proposed. (Attest.) WM. H. WAHL,

Secretary.

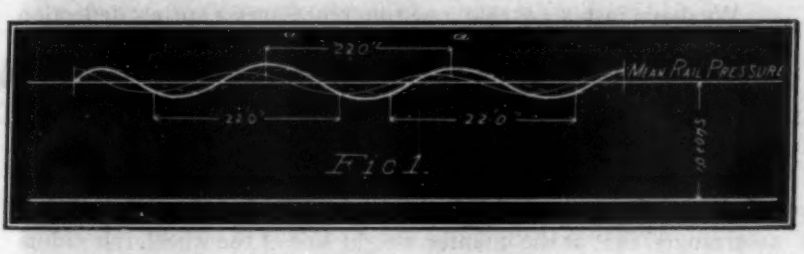
A NEW METHOD FOR THE ANALYSIS OF AIR AND GASES.—Otto Petterson (*Zeit. Analyt. Chemie*, **25**, 467), publishes the description of a gasometric method in which the measurements are made under constant pressure and constant temperature. For a description of this somewhat complicated apparatus, we must refer to the original memoir. W. H. G.

The HAMMER-BLOW in LOCOMOTIVES.

An ordinary locomotive, when balanced for the horizontal action of the moving parts by means of counter-weights disposed within the rim of the driving-wheel, cannot possibly be balanced in a vertical direction, excepting so far as the moving-gear has a vertical component of motion. Thus, the coupled-wheel of an ordinary four-coupled engine may be counter-weighted to balance the half-weight of the coupling-rod, for this revolves, in a sense, wholly about its crank-pin, but the driver, which is counter-weighted for the piston, cross-head, etc., is evidently out of balance vertically, owing to the fact that the piston and all parts having a rectilinear motion only, have no vertical component of motion, and so do not counteract the vertical action of the balance-weight in the rim. It is thus easily seen that the action of these parts would be best balanced by an equal and opposite force generated by similar moving parts. Theory and experiment alike show that a pair of engines working onto the same crank-pin and with their cylinder-axes inclined at right angles to each other are arranged most advantageously. It is difficult to see how such an arrangement could be applied to a locomotive, and even if applied, there would be set up so many other disturbing actions, due to inclined cylinders, as to more than neutralize any benefit obtained. It is, indeed, difficult at first sight to see in what way the vertically-unbalanced force in the wheel-rim can be eliminated in a practical manner.

Dismissing the first suggestion of inclined cylinders at right angles, as unsuited to the question of *locomotive* balancing, let us proceed to inquire whether the ordinary engine can be made to exert an even pressure on the rails at every period of the wheel revolution. The so-called "hammer-blow" in locomotives is the irregularity of the pressure exerted between the wheel and rail, which arises from the vertically-unbalanced action of the counter-weights placed in the wheel to neutralize the horizontal action of the piston and other moving parts. This vertical action of the balance-weights, as stated above, is not counteracted by any corresponding action in the moving parts, for of these the connecting-rod alone has any vertical movement due to the rotation of that

end which is attached to the crank-pin. The big end, then, directly, and the remainder of the rod to a lesser degree, has some influence in a vertical direction, but there still remains a large unbalanced action corresponding with the weights of piston, rod, and cross-head and part of the connecting-rod. Hence, when the balance-weight is at its nearest position to the rail, the vertical action adds to the pressure on the rail, whilst when at the opposite, or upper side of the wheel, a relief of pressure occurs, and it is this alternate addition and relief which constitutes the supposed hammer-blow. At high speeds, this action certainly partakes of the nature of a blow, but may be represented by a wave-line diagram, as in *Fig. 1*, where the mean weight on a wheel is being represented by the ordinates between the two parallel lines (say ten tons). The alternate variation of pressure is shown by the curved line, the space from crest to crest of wave being one



circumference of a driving-wheel, or twenty-two feet in the case of a seven-foot wheel.

In the diagram, the ordinates to the thin, full line, represent the rail pressures at every point of, say, the driving-wheel on the left side of an engine, the dotted curve giving the corresponding measurements for the right side, whilst the thick curved line is the mean of the two wheels, and serves to illustrate the action of the hammer-blow upon a bridge.

In order to fix the mind, let us assume the case of a seven-feet diameter single engine, with an unbalanced vertical action, resulting from forty-three pounds of a counter-weight acting at a radius of thirty-two inches, this weight being the excess left unbalanced by the vertical action of the connecting-rod, the total balance-weight perhaps, being eighty-six pounds. The centrifugal force due to forty-three pounds at sixty miles an hour, may be found by the well known formula, $F = \cdot 00034 . w . r . N^2$, when N, in this case, is

240 Then $F = 2{,}240$ pounds fully, say, one ton, which acts alternately upwards and downwards, with a difference of two tons, which will be the difference in length between the longest and shortest ordinates to either primary diagram in *Fig. 1*.

Now, an investigation into the deflection due to one ton load upon a spring twenty-four inches span, composed of twelve plates 5 x 3/8 inches, and a top plate, 5 x 1/2 inches, will show such deflection to be about one-sixteenth inch. The downward action of the balance is resisted by the rail, and cannot affect the steadiness of the engine. The upward action is resisted by the weight of the engine, acting through the springs. It must serve, then, to support the weight of the engine, and by so doing, it relieves the weight upon the rail, but as it now exceeds the weight of the engine, it cannot affect the steadiness in any way. The net result is simply a constantly varying pressure on the rail on either side of the mean.

We have just seen that one ton represents a spring deflection of one-sixteenth inch. It thus appears that an arrangement whereby the spring could be caused to vibrate one-sixteenth on each side of its mean deflection, would serve to equalize the rail pressure at the speed of sixty miles per hour. This spring action might be brought about by placing the wheel upon the axle eccentrically to the amount of one-sixteenth inch, the eccentricity being so arranged that at the counter-weight side of the wheel, the radius from the axle centre to the wheel tread, would be 3 feet $5\frac{15}{16}$ inches, whilst on the side opposite the radius is 3 feet $6\frac{1}{16}$ inches.

Then as the wheel revolved, or rolled along the rail surface, the axle centre would be raised and lowered through one-eighth inch, and with it, of course, the axle-box and spring-pin, so causing a constant action of the spring of one-eighth inch, representing the alternate addition and subtraction of one ton of load.

This, of course rests, on the assumption that the engine remains fixed in a vertical direction, and does not partake of the action of the springs.

The practical action, however, would not altogether conform to the assumption, and there would be to some extent a transference of the "hammer-blow" action to the other wheels of the machine, though to a very reduced amount, and also, to some extent, an absorption of the spring action by the inertia of the general mass of the locomotive. It has been stated above, that the excess of action on the rail cannot affect steadiness of running.

The relief action, however, of one ton, when in excess of the weight of the wheel and half-axle, etc., would lift the wheel from the rail, and its excess above the wheel-weight, etc., with centrally-fixed wheel, is resisted by the spring. A little thought will show that this can have no action in deflecting the spring, its action being merely to support the weight of the engine, relieving the rail-load to that amount. With an eccentrically-fixed wheel, however, the speed at which the centrifugal action was calculated would require to be constant. It may, however, be taken for granted that at low speeds, such as four or five miles per hour and upwards, the irregularity of action due to the radius difference of one-eighth would not be more severe than the present pressure variation existing in a normal engine. In the example of this paper, with seven-foot wheels the "blow" occurs every quarter second in each wheel, at sixty miles velocity. The two wheels together give blows following each other in one-sixteenth and three-sixteenths of a second respectively, the cranks, however, being at right angle. With six-foot wheels, the action is more severe and oftener repeated (F varying with r and N^2). Here we see one advantage attendant on the use of large wheels which may perhaps explain why in America the question of the hammer-blow has received far greater consideration than in England, where wheels of seven and eight feet are employed to run at speeds which in America are run with wheels of five feet and 5 feet and 6 inches. Hence the hammer-blow is at least of double the intensity in America, compared with England, and varies inversely as the square of the wheel diameter.

Assuming our reasoning to be correct in principle, it is clear that for every speed there is a certain eccentricity which will render nugatory the present unbalanced counter-weight action. It is by no means uncommon to find the eccentrics of steam-engines made compound, the main eccentric driving the valve, being seated upon an inner and smaller eccentric on the shaft. By this device, the throw of the combination may be varied between limits by any desired amount, depending upon the angular displacement of the eccentrics relative to each other.

The application of this principle to the axle-seat of a locomotive wheel would, if it could be safely and practically effected, supply a means of giving to such driving-wheel any desired eccentricity

between nil and a maximum of, say, the above calculated one-eighth inch. A suitably designed governor, revolving at a speed proportionate to the forward velocity of the engine, could be so arranged as to vary the eccentricity to suit the speed, exactly as in the case of the steam-engine.

The writer, however, does not propose this as a practical solution of the question, so much as an indication of the principles involved. It does, however, appear that a certain speed might be calculated for, and a fixed eccentricity given to suit the speed at which the engine will run. So arranged, an engine would run its calculated thirty, forty, sixty or seventy miles per hour with perfectly even rail pressure, and at no speed would this vary so much as in a normal engine.

Fast express engines would be best ex-centred at, say, a mean speed of sixty, local trains for forty miles, whilst freight engines would count for, say, twenty. We have seen that in a large wheel there is a total action of two tons; this seems severe, but it does not appear probable that such action can be very dangerous to bridge structures. The real action of the hammer-blow, as shown by the diagram, is gradually imposed; excess and deficiency of rail-pressure and the mean culminations of the two wheels, as shown by the thick lines, may be taken as the true vibratory cause. Should these culminations synchronize at the train speed with the period of oscillation of the bridge, the effect might be serious, especially if the culminations also at the same time coincided with floor-beams. Any want of coincidence between these three, might entirely nullify vibration, by their mutual interferences. Such a concomitancy of vibration, panel length, and culminations *a*, *a*, as above described, is not likely to occur, and in considering the question of bridge vibration, it would appear that if anything be done, it should be in the direction of so arranging panel lengths, as not to correspond, at average speeds of train, with the period of vibration of the bridge, or with wheel circumferences—this latter possibly the better safeguard of the two.

In conclusion, the writer would state that there appears every reason to believe that the vertically unbalanced action of locomotives is very severe. The writer's house is only forty yards from the centre of a double-track railroad, on which some trains pass daily at a speed of sixty miles or upwards.

The vibration set up apparently coincides with the wheel revo-

lutions and is very severe and of a vertical nature in the ground, but great differences are observable in different engines.

Heavy four-coupled engines set up greater vibrations than single engines. The four-coupled wheels are from 5 feet 6 inches to 6 feet 6 inches diameter. The single engines have seven-foot wheels and also inclined cylinders. Now, whatever may be the faults of inclined cylinders, it is easy to see that the vertical action of the steam against the cylinder-covers and through the connecting-rod, upon the rail, will serve to counteract the "hammer-blow," which must also be less severe than in the smaller wheels.

These appear to be the chief reasons why the vibratory actions of the small wheels is greater, apart from their greater frequency.

In submitting his views of the question for the consideration of American engineers, the writer is confident they will receive fair treatment and obtain a hearing, perhaps, better than they would receive in England, where conservatism of ideas is more marked. With the apparatus illustrated in the JOURNAL OF THE FRANKLIN INSTITUTE, it might well be worth while to experiment with eccentric wheels; determining the amount needful in an actual case, to counteract all variation on the dynamometer. The effects due to obliquity of connecting-rod would require elimination by taking diagrams also with centrally-fixed wheels. The difference between these and the diagrams from the ex-centred wheels would mark the eccentric action. Such a series of experiments would be of great interest and service to scientific engineers. The writer anticipates that the final result of any thorough inquiry will be in favor of larger wheels towards which American practice is now tending, and which certainly appear to show good cause for their existence in the already-mentioned greater attention given to the "hammer-blow" in America than in England.

P. S.—It might be added, that as the variation of pressure on the rail is shown by a wave-diagram, it cannot amount to a *blow* and cannot therefore possibly injure the rails, except in so far as they are generally weak. For "how does the rail know" that the heavier *pressure* at the time the supposed *blow* is taking place is not due to a generally heavier locomotive without a blow. At most, the effect of the blow is to increase the pressure on the rail about twenty per cent. in places and reduce it twenty per cent. in others. (This with, say, five and one-half-feet wheels.) Hence a rail twenty per cent. stronger is needed for the increase may come anywhere. With such a stronger rail, the hammer-blow would have no further effect than a perfectly balanced wheel on the normal rail.

W. H. BOOTH.

Huxton, near Manchester, England, November, 1886.

ELIZABETH THOMPSON SCIENCE FUND.

This fund, which has been established by Mrs. Elizabeth Thompson, of Stamford, Conn., "for the advancement and prosecution of scientific research in its broadest sense," now amounts to $25,000. As the income is already available, the Trustees desire to receive applications for appropriations in aid of scientific work. This endowment is not for the benefit of any one department of science, but it is the intention of the Trustees to give the preference to those investigations, *not already otherwise provided for*, which have for their object the advancement of human knowledge, or the benefit of mankind in general, rather than to researches directed to the solution of questions of merely local importance.

Applications for assistance from this fund should be accompanied by a full statement of the nature of the investigation, of the conditions under which it is to be prosecuted, and of the manner in which the appropriation asked for is to be expended. The applications should be forwarded to the Secretary of the Board of Trustees, Dr. C. S. Minot, 25 Mt. Vernon Street, Boston, Mass., U. S. A.

(Signed) H. P. Bowditch, *President.*
Wm. Minot, Jr., *Treasurer.*
Francis A. Walker.
Edw. C. Pickering.
Charles Sedgwick Minot, *Secretary.*

On the Presence of Oxygen in Silver.—Van de Plaats (*Rec. de Trav. Chim.*, **5**, 212) has critically reviewed the work of Dumas, from which that chemist was led to conclude that silver always retains oxygen after fusion in presence of that element. The silver was heated to ebullition in an unglazed crucible, by the application of an oxy-hydrogen blow-pipe flame to its surface. The almost boiling metal was then poured into cold water in a tall, cylindrical vessel, at the bottom of which was placed a silver crucible. About ten grammes of this granulated silver was then heated to the softening point of Bohemian glass, successively in currents of air, hydrogen and carbon-monoxide, and subsequently in a vacuum, the gases in each case being carefully purified. The experiments showed that silver purified according to the method of Stas does not sensibly decrease in weight when heated in a vacuum to 600° C. for about three hours, and the weight of the silver did not vary by heating in the gases named. W. H. G.

CAN THE ORIGINAL REIS TELEPHONES TRANSMIT INTELLIGIBLE ARTICULATE SPEECH?

By Prof. Edwin J. Houston.

A brief note on "Some Additional Facts Concerning the Reis Articulating Telephone," published by me in the JOURNAL OF THE FRANKLIN INSTITUTE, July, 1886, has called forth the following correspondence from Dr. Theodore Stein, and Mr. John R. Paddock, which is here given:

From this correspondence, it will appear that Dr. Stein calls in question the possibility of transmitting articulate speech by the use of the original apparatus referred to by Mr. Paddock in the note above-mentioned.

Although the author has not personally repeated the experiments of Mr. Paddock with the original apparatus of Reis, yet he is disposed to give full credence to the statements of Mr. Paddock, because he (the author) had, prior to the publication of Mr. Paddock's letter, held an almost uninterrupted and quite intelligible conversation, continuing for some five or six minutes, in which questions and answers were given and received, by the use of a transmitter, which was an exact reproduction of the Reis bored-block transmitter, and employed the platinum contacts found on the Reis apparatus; and also because he does not see any essential structural differences between this form of transmitter and that in extensive commercial use to-day by the Bell Telephone Company.

Although the real point called into issue by Dr. Stein's correspondence is limited to the practicability of one of the first of the Reis instruments as an articulating telephone transmitter, yet, it will be observed that he acknowledges that the later forms of Reis apparatus—forms described and given to the world long prior to the date of Bell's alleged invention of the articulating telephone—will transmit intelligible, articulate speech. This being the case, even if Dr. Stein established his point as to the inoperativeness of the original Reis instrument, which we fail to see that he has done, it still remains a fact that an instrument called by Reis, its inventor, a telephone, and claimed by him as an instrument intended to transmit articulate speech, employed by him to

transmit articulate speech, and heard by others during Reis's life-time to transmit such speech, *still transmits such speech*, then Reis, and not Bell, is the real and true inventor.

It is perhaps, difficult for one not living in America to credit the extent to which, at the present moment, the courts have sustained the legality of Mr. Bell's claims to the invention of the articulating telephone. If they had only awarded to him patent-rights for improvements on the electrical transmission of speech, the point we have made here would lose its significence; but in America, Bell at present is held, from a legal standpoint, to be the first and only inventor of the telephone, and is awarded *the sole legal rights to employ electricity in the transmission of speech*. This we contend, in view of the above, is certainly at fault from a scientific standpoint, and we are disposed to believe from a legal standpoint also.

We will permit the correspondence, however, to speak for itself:

FRANKFURT A. M., den 21. Juli, 1886.

HERRN PROFESSOR EDWIN J. HOUSTON, IN PHILADELPHIA.

GEEHRTER HERR!—Ich erhielt vor einigen Wochen einen Artikel von Ihnen, betitelt: "Some Additional Facts Concerning the Reis Articulating Telephone," und erlaube mir Ihnen dagegen einen in No. 7 meiner Zeitschrift '*Elektrotechnische Rundschau*' enthaltenen Artikel zu senden, aus welchem Sie meine Ansichten über den vorliegenden Fall ersehen können. Ich würde Ihnen sehr dankbar sein, wenn Sie mir eine Mittheilung (in englischer Sprache) zukommen lassen wollten, ob Sie sich von den Angaben des Mr. Paddock persönlich überzeugt haben, denn ich kann mir nicht denken, dass man mit dem Instrumente, welches ich selbst früher besessen habe und mit welchem Mr. Paddock seine Experimente machte, in der Weise, wie in Ihrem Artikel geschildert, ganze Sätze in deutlicher Vernehmbarkeit übermitteln konnte. Mir persönlich war es, obwohl ich den Apparat viele Jahre besass, niemals möglich, mit demselben artikulirte Worte zu übertragen. Auf der Münchener Elektrizitäts-Ausstellung, 1882, woselbst ich den Apparat ausgestellt hatte, beschäftigten wir uns bei dem betreffenden Prüfungen mit grosser Mühe, mit dem Apparate gesprochene Worte zu übermitteln, es gelang uns aber nicht. Auch ist mir nicht erinnerlich, je gehört zu haben, dass Professor Böttger oder Reis selbst mit diesem Instrumente Worte übermittelt hätte. Ich habe zwar selbst mit anderen Apparaten von Reis im Jahre 1862 übermittelte artikulirte Worte an dem Reis'schen Receiver gehört, jedoch war dies mit dem vielfach verbesserten Instrumente, welches in meiner Zeitschrift '*Elektrotechnische Rundschau*,' Band I, No. 4, Seite 55, Figur 7, (in der Bibliothek des FRANKLIN INSTITUT vorhanden) abgebildet ist.

Ich sehe Ihren betreffenden gefälligen Nachrichten entgegen und zeichne,

mit vorzüglicher Hochachtung,

DR. THEODOR STEIN.

Translation.

FRANKFURT A. M., July 21, 1886.

PROFESSOR EDWIN J. HOUSTON, PHILADELPHIA.

DEAR SIR:—I received, several weeks ago, an article of yours, entitled "Some Additional Facts Concerning the Reis Articulating Telephone," and, in return, I take the liberty of sending you an article, which appeared in No. 7, of my journal, the *Elektrotechnische Rundschau*, from which you will perceive what my views are on the subject under discussion. I will be greatly obliged if you will inform me whether you have personally satisfied yourself of (the accuracy of) Mr. Paddock's declarations, for I cannot think (it possible), with the instrument that formerly was in my possession and with which Mr. Paddock made his experiments, that anyone should have been able to transmit entire sentences intelligibly, in the manner described in your article. Although I had possession of the apparatus for many years, I was never able to transmit articulate speech with it. At the Electrical Exhibition in Munich, in 1882, where I exhibited the apparatus, we made the greatest efforts, while the tests were being conducted, to transmit spoken words with the apparatus—but in vain; and I do not remember ever to have heard that Professor Böttger, or Reis himself, had succeeded in transmitting speech with this instrument. With other instruments of Reis, in 1862, I have heard spoken words at the Reis receiver, but this was with the instrument of much improved pattern, which is illustrated in my journal, the *Elektrotechnische Rundschau*, Volume I, No. 4, page 55, and which you may find in the Library of the FRANKLIN INSTITUTE.

Anticipating your courteous advices in the case, I subscribe myself,

With high esteem,

(Signed) DR. THEODOR STEIN.

ELEKTROTECHNISCHE RUNDSCHAU,
Redaktion · Kaiser Strasse 25, Frankfurt a. M.

FRANKFURT A. M., den 23. Oktober, 1886.

HERRN PROFESSOR EDWIN J. HOUSTON, IN PHILADELPHIA.

SEHR GEEHRTER HERR!—Ich habe durchaus nichts dagegen einzuwenden, wenn Sie den Ihnen am 21. Juli d. J. geschriebenen Brief veröffentlichen.

Trotz Ihrer gefälligen Mittheilung, dass Sie selbst keinen Zweifel in die Angaben des Herrn Professor Paddock setzen, muss ich bei meiner Behauptung stehen bleiben, dass man mit dem Apparate, welchen ich Herrn Professor Thompson überlassen habe und den Herr Professor Thompson an die Overland Telephone Company weiter gegeben hat, nicht, wie mit den neueren Bell-Telephonen, Worte oder ganze Sätze, auf irgend eine Entfernung, auf die man nicht durch direkte Sprachvermittelung hören kann, zu übertragen vermag. Solches ist nur mit den Reis'schen Telephonen zweiter Form möglich (abgebildet in Thompson's Buch: *Philip Reis, Inventor of the Telephone*, Seite 86), weil man an diesen Apparaten die Membran beliebig spannen kann, und weil hier der Platinkontakt nicht, wie bei meinem, Herrn Professor Thompson überlassenen Apparate, etwas von der Membran absteht, sondern direkt nach dem Gesetze der Schwere auf der Membran ruht, mithin hier

keine Stromunterbrechungen stattfinden, sondern nur Stromschwankungen, wie solches das Desiderium bei Hervorbringen von artikulirten Worten oder Sätzen ist.

Die kürzlich publicirte Beobachtung von Francis E. Nipher, dass man bei einer bestimmten Spannung der Membran mittelst des Reis'schen Telephons Worte übertragen könne, halte ich für vollkommen richtig und bin überzeugt, dass jedes Mal, wenn, wie vor 25 Jahren, Worte oder kleine Sätze mit dem Reis'schen Telephon zweiter Ordnung übertragen haben, die Membran richtig gespannt war; es war immer ein Zufall, wenn dies geschah, da Reis selbst in den Vorträgen über sein Telephon auf die richtige Spannung der Membran kein besonderes Gewicht gelegt hatte.

Wenn Sie auch diese Mittheilungen im JOURNAL DES FRANKLIN INSTITUTS publiciren wollen, habe ich nichts dagegen einzuwenden.

Ich bin mit vorzüglicher Hochachtung,

Ihr ergebenster DR. STEIN.

Translation.

ELEKTROTECHNISCHE RUNDSCHAU,
Editorial Office: Kaiser Strasse 25, Frankfurt a. M.

FRANKFURT A. M., October 23, 1886.

TO PROFESSOR EDWIN J. HOUSTON, IN PHILADELPHIA.

DEAR SIR:—I have not the slightest objection to the publication of my letter to you, dated July 21, 1886.

Notwithstanding your statement that you have no reason to doubt the accuracy of the declaration of Professor Paddock, I must stand by my assertion, that, with the apparatus which I gave to Professor Thompson, and which he subsequently gave to the Overland Telephone Company, it is not possible, as it is with the more recent Bell Telephone, to transmit words or whole sentences to any distance beyond that at which the spoken words may be heard directly. Such transmission is only possible with the Reis telephone of the second form (illustrated in Thompson's book: *Phillip Reis, Inventor of the Telephone*, page 86,) for the reason that in this apparatus the membrane may be tightened to any extent, and also because in this, the platinum-contact does not stand-off somewhat from the membrane, as in the apparatus which I gave to Professor Thompson, but rests directly upon the membrane by gravity. By reason of this, there are here no interruptions of the current, but only fluctuations (undulations) in it, which is the desideratum for the production of articulate words or sentences.

I consider the recently-published observation of Francis E. Nipher, that, by giving the membrane a certain tension, it is possible to transmit words with Reis's telephone, to be quite correct; and I am convinced that every time we succeeded, 25 years or more ago, in transmitting words or short sentences, with the second form of the Reis telephone, the membrane had just the right tension. It was always an accident when this happened, for Reis himself, when lecturing on his telephone, attached no particular importance to the proper tension of the membrane.

Should you wish also to publish this communication, you are at liberty to do so. I am with high esteem, etc., DR. STEIN.

A careful perusal of Dr. Stein's correspondence will show that while he acknowledges that the original apparatus referred to is the apparatus now in the possession of Mr. Paddock, and with which Mr. Paddock tried these experiments in controversy, he denies that such apparatus can possibly transmit articulate speech. This denial is based on the fact that Dr. Stein himself utterly failed to transmit articulate speech with this apparatus although he repeatedly endeavored to do so. This we submit may be sufficient reason for Dr. Stein to call into question the probability of the correctness of Mr. Paddock's experiments, but it is not sufficient to permit him to question the possibility of such experiments, unless he can point to some sufficient reason, based on the nature of the apparatus employed, which would render the accomplishment of such results impossible.

In looking for the cause of Dr. Stein's failure to transmit articulate speech with the original Reis transmitter, we have read his letters, especially that of October 23d, with great care. Not willing to take our own translation, we have asked Dr. Wm. H. Wahl, the Secretary of the FRANKLIN INSTITUTE, to give a literal translation of the same, which he has kindly done.

Dr. Stein himself bases the alleged inoperativeness of the original instrument on the structure of its contact-point. Speaking of the Reis telephone of the second form, which is similar to that made by Koenig, of Paris, he says that transmission of speech is only possible with this form, "because in this, the platinum-contact does not stand-off somewhat from the membrane, *as in the apparatus which I gave to Professor Thompson* (our italics), but rests directly upon the membrane by gravity."

This structural peculiarity will be better understood from an inspection of *Fig. 1*, the form referred to in Dr. Stein's letter. Doubtless here is the cause of Dr. Stein's failure. If, by the above quotation, he is to be understood as meaning that the platinum-contact stands off from the membrane in the sense of not touching it, when no speech is being transmitted, then no further inquiry need be made as to the cause of failure. He has failed, because of his ignorance of the structure of the apparatus with which he is experimenting—an ignorance which is inexcusable in the light of Reis's published statements, or of the published statements of his contemporaries. Dr. Stein fails because he is experimenting *with*

an open-circuited transmitter. That the apparatus was never designed to be employed in this manner, the following translation of an article by Prof. Böttger, in the *Polytechnisches Notizblatt*, respecting a Reis transmitter of this form, will clearly show:

"A little light box, a sort of hollow cube of wood, has a large opening at its front side and a small one at the back of the opposite side. The latter is closed with a very fine membrane (of pig's smaller intestine) which is strained stiff. A narrow springy strip of platinum-foil, fixed at its outer part to the wood, touches the membrane at its middle; a second platinum strip is fastened by one of its ends to the wood at another spot, and bears at its other end a fine horizontal spike, *which touches the other little platinum strip where it lies upon the membrane*" (the italics are my own).

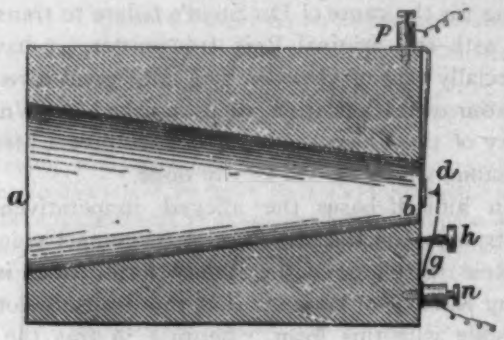


FIG. 1.—Bored-block Transmitter.

So also in a description of the Reis-Legat apparatus, published in the *Zeitschrift des deutsch-österreichischen Telegraphen-Vereins* 1862, the following statement is made bearing on this point: "In the condition of rest, the contact, *d g*, is closed, and a delicate spring, *n*, holds the lever firmly in the position of rest."

It is so difficult for us to believe that Dr. Stein could have so blundered as to experiment with an open-circuited apparatus that we have endeavored to find some other interpretation for the passage before quoted. We have therefore tried to construe his meaning to be that in the earlier form of apparatus the platinum-contact, being supported by a spring, stands off from the membrane more than it does in the later form, where it rests directly against the membrane by the action of gravity. The antithesis of

resting directly on the membrane, to the standing off of the same is, however, in our opinion, in the way of such an interpretation. Nor are we clear whether Dr. Stein merely intends to contrast the action of gravity with that of a spring, and to say that the latter is far more prompt in its action, and that its use is therefore attended with fewer breaks in the circuit than is the spring. But such a difference is one of degree rather than of kind, and the degree can be made almost imperceptible if the regulating-screw *h*, *Fig.* 1, provided for the purpose, is employed to give the spring such elastic pressure as to enable it to freely follow the movements of the diaphragm. Does Dr. Stein understand the function of this screw, and if he does, where is the pertinence of his remarks above quoted as to the operativeness of the one form of apparatus and the inoperativeness of the other?

As to Dr. Stein's insinuations respecting the "distance beyond that at which the spoken words may be heard directly," we are unwilling to insult the intelligence of our readers by stating that in experiments of this character, where the honesty of the experimenter is assured, any uncertainty from such source is impossible.

We here append the following letter from Mr. Paddock, in which he describes at greater length, experiments with the particular form of the Reis apparatus in question.

NOVEMBER 29, 1886.

PROF. E. J. HOUSTON,

FRANKLIN INSTITUTE, Phila.

The communications of Dr. Stein relative to my experiments with the original Reis instruments having been called to my attention, I take pleasure at this time in furnishing additional information in regard to the same, which I had already promised to do in a former letter. At that time, I had succeeded in transmitting a sentence in English of twenty-three words while the instruments were operating in exact conformity to the method Reis describes in his lecture before the Physical Society of Frankfort A.-M. Since then, the extent to which these instruments will transmit articulate speech has been farther investigated and the results carefully tabulated.

These results show that while this first form of the Reis telephone is a very imperfect instrument, still it is able to transmit certain words and sentences in common use, in our language to-day and to this extent at least is capable of transmitting articulate speech. In order that my meaning may be made the clearer, I will give examples of words which have been transmitted, indicating the elementary sounds of speech to which the instruments responded, and those to which they did not; and will also append copies of accurate drawings of the instruments themselves. (*See Figs. 2 and 3.*)

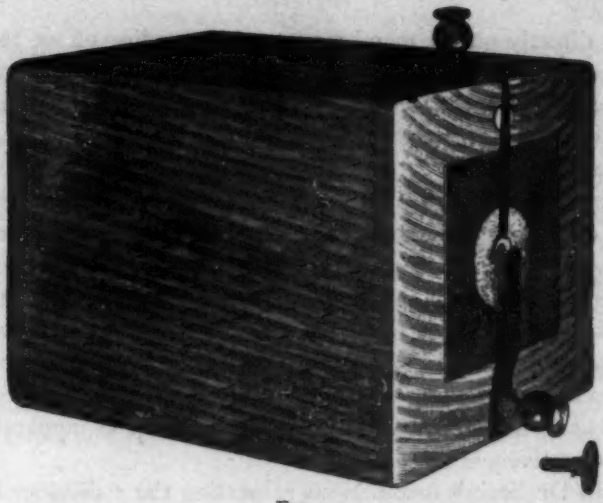


FIG. 2.

Spoken at the Transmitter.	*Heard at the Receiver.*
Rŭn	Rŭn
Sŭn	—ŭn (s, could not be heard)
hăt	—ăt (h, could not be heard)
păt	păt
Căt	kăt
better	better
letter	letter
Fetter	—etter (F, could not be heard)
talking!	talking
Walking!	Walking
Shouting!	———ing (shout, not heard)
Phonograph!	Phonograph
Telegraph!	Telegraph
Philadelphia!	Philadelphia
Boston!	———ŭn
New Jersey!	Nū— ———
Maryland!	———
Virginia!	———
Ohio!	O–io
Connécticút!	Connecticut
The Indianna State Bar proposes to hold a meeting.	—— Indianna ——— — ——— — — —— ——ing.
Governor Hill was elected by ten thousand majority!	Gov—nor —— —lected — ten thousand majority!
Did you get my telegram I sent you yesterday?	Did you get my telegram I sent you yesterday?

In order to obtain such results as these a number of conditions must be complied with, which require much time and patience and involve many dis-

FIG. 3.

couraging failures, in view of which it is not surprising that conflicting statements should exist regarding the efficiency of the instruments. In the first place, the knitting-needle receiver, in order to be heard distinctly, requires at

least five or six times the *Electro-Motive-Force* used with ordinary magneto receivers, otherwise many of the smaller vibrations will be lost to the ear—simply because they are beyond the reach of hearing. The resistance of the circuit also must be kept very low indeed. The reason for this is evident when we consider that all sounds of the receiver are caused by the variations in the electric current produced at the transmitter, and that these variations must be of great amplitude *in order to render such a receiver as the Knitting-Needle—audible*. Hence it is desirable to concentrate the greater part of the resistance of the circuit at this point. It is also evident that any attempt to obtain louder sounds from the receiver by increasing the battery, while resistances at all comparable with that at the transmitter remain in the circuit, will be useless.

To obtain the best results, the instrument should be spoken to in *an exclamatory tone of voice* and with distinct articulation, so as to cause the membrane to vibrate strongly and rapidly. I had myself been accustomed to speak in well modulated tones of the voice until I found by numerous trials that the former method produced the best results in this instrument. This has not been my experience with other forms of the Reis instruments.

The requisite tension of the membrane I have found to be necessary as Dr. Stein remarks. But in the absence of any mechanical means, such as is furnished by the later forms of the Reis apparatus, I have obtained the desired tension of this membrane by exposing the instrument for a short time to a dry and warm current of air, or still better, to the direct rays of the sun, without detaching the membrane in any way from the wooden block to which it is secured. Under these conditions any degree of tension can be obtained which is desired, and care only has to be exercised that this tension shall not be *too great?*

The general impression has been that the tighter this membrane can be stretched the more nearly it approaches the condition of a metallic diaphragm; but this is not the case, as an animal membrane under great tension assumes a fundamental vibration of its own, which seriously interferes with its transmitting all the vibrations of the voice.

In the later forms of the Reis transmitter (with which I am quite familiar) the use of gravity in causing the weight of the hammer-piece to regulate the movement of the contact-point is, no doubt, a decided advantage over the elasticity of a metal strip used in this first form, because in this form there is a liability to irregular breaks in the electric current. Notwithstanding this, when such breaks are *timed and spaced by the action of the voice itself*, they do not of necessity prevent the transmission of speech, as is evidenced by my experiments in which the contacts are heard to part, and sparks are seen to pass between them. The explanation in this instance may be that when spoken to in the manner described, the membrane in its returning phase of vibration does not reach the initial point before it is again forced forward by a new wave of condensation; and thus the breaks in the electric current are of exceedingly short duration, and correspond as to point of time with the air vibrations causing them—in other words they are timed and spaced by the voice itself.

To my own mind there can be no sharply defined line drawn between the

first and second form of the Reis instruments whereby the sound can be said to transmit speech but the first not; photographic records of the motions of the contacts in a modern transmitter show that *breaks* are continually occurring during the transmission of speech, and recent experiments of my own indicate that there is but *one method* common alike to all forms of Reis and to modern battery transmitters, and that this method may involve undulations, interruptions and breaks at successive moments while transmitting artificial speech in all of its complex forms.

In conclusion I would say that in these tests with the Reis instruments no communication of direct speech was possible—the transmitter and receiver being in distant buildings—the experiments are open for verification to the scientific public. With esteem and regard,

Very truly yours, JOHN R. PADDOCK.

It will be noticed that the condition insisted on by Mr. Paddock, as essential to the successful use of this form of Reis transmitter, viz., "The resistance of the circuit must be kept very low indeed," differs radically from the manner in which Dr. Stein appears to have used the instrument, viz., with the platinum-contact borne by the spring standing off some little distance from the platinum-contact placed on the membrane, that is to say an open circuit and with a practically infinite resistance in the circuit. Under such conditions of course Dr. Stein must, of necessity have failed in attaining transmission of articulate speech.

Since placing the above correspondence in the hands of the editor of the JOURNAL OF THE FRANKLIN INSTITUTE, for publication, I have received from Dr. Stein an article concerning my publication before referred to, criticising both my printed references thereto, and Mr. Paddock's experiments.

In this article Dr. Stein disposes of the question apparently to his entire satisfaction with the remark that such an instrument cannot produce undulatory currents, and therefore cannot, of course, transmit speech. In America, where this, by no means substantiated, opinion has been so carefully and industriously disseminated in the non-scientific community, by the legal friends of Bell, we would not be surprised at its reiteration, but coming, as it does, from Germany, we must confess to considerable surprise.

Dr. Stein adds nothing, in our opinion, in this article in the way of substantiating his assertions. Besides indulging in personalities, and impugning motives, the article is so lacking in what we may call the amenities of scientific controversy, that we do not think it worth our while to notice it further than what we have done above.

Central High School, Philadelphia, December 8, 1886.

BOOK NOTICES.

SHORT LECTURES TO ELECTRICAL ARTISANS. By J. A. Fleming, M.A., D. Sc. E. & F. N. Spon. 1886.

In this excellent little book the author has taken a new departure from the old stereotyped explanations, descriptions, cuts, etc., which have been so often repeated and published that they are now of little interest save as historical relics. He treats the subject in a new and apparently original way, which adds greatly to clearness and increases the interest of the book to readers not already versed in the subject. As the title implies, the book is for electrical artisans and is entirely free from abstruse mathematical expressions, formulæ or complicated theories, the subject being treated clearly and concisely, and, though covering considerable ground, it is limited principally to such information as will be of every-day use to the practical electrician. Although written for electricians, the subject is treated in such a way that it may be readily understood by any one not familiar with the subject, while, at the same time, it contains some matter that may be of considerable interest and use to experienced electricians.

The first lecture is devoted to a description of the principles and laws of magnetism. It includes a clear explanation of how magnetism may be measured in units, this unit being a small force, 1,000,000 of which are equivalent to about two and one-quarter pounds. He shows how this unit may be represented by lines of force, each line representing one unit, and that therefore intensity of a magnetic field is the number of such lines per square inch or centimetre; that the "pull" in pounds in a magnetic field of known strength may readily be calculated.

He describes the important terms permeability, susceptibility, magnetic induction and resistance, as follows: in speaking of a piece of iron in a magnetic field, he says: "Lines of force find a more easy passage through the iron than through the air. On account of this behavior the iron is said to have a greater permeability than air, or greater conductibility for lines of force, or less magnetic resistance. The soft iron is said to acquire magnetism by induction, whilst it is in the field. The intensity of this induced magnetism divided by the strength of the field is called its magnetic susceptibility. The number of lines of force passing through one square centimetre of cross-section of the iron is called the magnetic induction. We have then two relations:

$$\text{Intensity of magnetism} = \text{susceptibility} \times \text{field strength};$$
$$\text{Induction} = \text{permeability} \times \text{field strength.}$$

"The most simple way to regard the 'susceptibility' and 'permeability' of iron or steel is to consider these quantities as numbers, by which we must multiply the magnetizing field in order to obtain the intensity of magnetization, and the number of lines of force per square centimetre through the iron respectively, provided this be in the form of a long, thin bar, placed along the lines of force in the field." He gives the following figures: "From experiment

it appears that the greatest number of lines of force which a long bar of soft annealed iron, one square centimetre in cross-section can hold, is about 18,000 C. G. S. units. This induction bestows on it a maximum magnetization of 1,400 C. G. S. units."

In lecture II, is given a clear description of the magnetic effects of electrical currents, including Oersted's, Ampère's and Faraday's experiments, the galvanometer and the induction between currents and magnets. The following practical rule is given for determining the direction of the current by the direction of the lines of force, that is, by a compass needle: "Suppose a watch strung on the wire so that the current goes in at its face and comes out at its back, then the direction of the lines of force is in the direction in which the hands rotate." The generation of currents by cutting lines of force is clearly and briefly explained, both for the ordinary and the unipolar machines. The practical rule which he gives for finding the direction of the current induced, is well worth remembering, and is original with the author: if the thumb, fore- and middle-finger of the right hand, be held at right angles with one another, the middle-finger will point in the direction of the current if the thumb points in the direction of motion of the wire, and the fore-finger in the direction of the lines of force, considered as emanating from the north pole. He shows how the electro-motive force induced may be calculated, as one volt is generated when a wire cuts lines of force at the rate of 100,000,000 per second. It is also described how the ampère is determined from the magnetic effects. The self-induction of a current is compared to inertia, as of a heavy fly-wheel, which cannot be started or stopped suddenly without evidence of its inertia. This increased E. M. F. is compared to the sudden increased pressure in the hydraulic ram, or to that which causes the bursting of a water-pipe at a sudden closing of the stop-cock.

Lecture III, treats of electro-magnetism and the suction of a core into a solenoid. Weber's theory of the magnetism of molecules is illustrated with a glass tube filled with fine steel filings, which represent the molecules. The effect of permanent magnetic "set" of the molecules in steel as distinguished from soft iron, is compared to the permanent set in the torsion of a lead-wire as distinguished from a brass wire. In conclusion, he describes a method for measuring the intensity of a magnetic-field in dynamos.

In Lecture IV, are described various forms of magnets for different purposes. In speaking of magnetism, he says: "In the best dynamos, as now designed, the number of lines of force is about 6,000 to 10,000 per square centimetre." It is not stated, however, whether this is the magnetism in the core, or in the field, of the armature. We presume he means the former, as it then agrees with that found by actual experiment in some Edison and Weston machines. In reference to cast- and wrought-iron, he notes an experiment of Kapp, with two exactly similar machines, differing only in the iron. He found that the exciting current had to be more than doubled to generate the same E. M. F. with the cast-iron magnets; and with the same exciting current, the E. M. F. was eighty and 100 volts for cast and wrought-iron respectively. The lecture concludes with a description of secondary induction-coils and their application in practice, to systems of distribution, commonly known

as the Gaulard & Gibbs (owned in this country by Westinghouse), the Zipernowski-Deri, and others. In speaking of the sparking, jumping or striking distance, he says that 1,000 volts will discharge across ·005 inch between points, and that, generally speaking, the striking distance varies as the square of the E. M. F.

In Lecture V, the author gives a very complete *résumé* of the subject of units of measurements, both absolute and practical. Regarding the ordinary British system of weights and measures, he remarks that: "They seem to comply with the condition of creating the utmost possible waste of brain-labor in performing the simplest calculation." He compares the E. M. F. to differences of level, or head of water, expressed in feet, or what he terms the water motive-force. In discussing resistance, it is shown what is meant by resistance being a velocity. The lecture concludes with a summary of the units and their values, in a practical form. Among a few other units, not usually found in tables, is the following: "One *gauss* is strength of field in which a length of 1,000,000 centimetres of wire moving across the lines with a unit velocity, develops one volt E. M. F. = 100 times strength of one C. G. S. field. Strongest dynamo field is about 100 gausses." This unit, therefore, represents the intensity of a field having 100 lines of force per square centimetre, or about 650· per square inch. From the FRANKLIN INSTITUTE tests of dynamos, it appears that the field-intensity of the Edison and Weston machines was about forty to twenty-seven gausses.

Lecture VI, treats of practical measuring instruments. He very appropriately calls the voltmeter a coulomb-meter, a name which was suggested in this country some years ago, and which ought to replace the old term, as it is more appropriate and cannot be confounded with the term voltmeter. For the copper voltmeter, he recommends an addition of about five per cent. of sulphuric acid to the strong solution of sulphate of copper; density of current at least two square inches per ampère, if only one side of the plate is used; weigh only that plate which has the deposit; gain of weight in grams divided by ·00032709, gives the quantity in coulombs. This last figure does not agree very well with the determination of Kohlrausch, made in 1884, which is ·0003281. In discussing single coil galvanometers, he gives the following practical rule: The current in ampères is equal to $\frac{5}{2\pi}$ × radius of circle in centimetres × strength of magnetic field at its centre in C. G. S. units. By the latter is meant the number of lines of force per square centimetre. This is followed by a clear and simple description of the principles of the tangent galvanometer and its calibration, without the use of formulæ or trigonometric functions. The lecture concludes with the description of some of the practical ampère- and voltmeters, with the principles governing them. In using the electro-dynamometer for alternating currents, he states that, in certain cases, the real value is ten per cent. less than that indicated.

In Lecture VII, he makes a very good analogy between the fall of potential in a circuit and the fall of pressure in a water-main. This is followed by discussions of voltmeters, the most interesting of which is that of the potentiometer, a simple and effective instrument for measuring accurately potential and current, even very large currents.

In the discussion of resistance coils, he gives some useful figures regarding the size of wire to be used. To measure low resistances, as that of armatures, he recommends sending a weak, constant, battery current, through the armature, and an accurately determined resistance of ·01 ohm in series with it; touching the terminals of a high resistance galvanometer to both of the two terminals of each successively, then the deflections will be proportional to the resistances. In speaking of iron for voltmeters, he says: "A short, squat piece of iron has, so to speak, no magnetic memory. Its past magnetic history is immediately obliterated when placed in a new magnetic field."

In Lecture VIII, he mentions that storage batteries do not store electricity, but energy. A very good description of primary and secondary batteries, polarization and standard cells, is given. He says that the E. M. F. of a battery, in volts, multiplied by 988,960, gives the greatest theoretical amount of energy in foot-pounds, which can be produced per pound of zinc in that battery. With a motor, Joule showed that only one-seventh of this was obtainable in practice. In storage batteries, made of lead grids filled with the oxide, he says the proper charging current is about two ampères per square foot of negative plate, including the surfaces on both sides of the plate; for discharging, about three ampères per square foot. These cells give about 25,000 to 35,000 foot-pounds per pound of plates reckoning both positive and negative together; in the Planté type only 12,000.

In Lecture IX, in describing motors, he says that Joule obtained with a Grove battery 331,400 foot-pounds per pound of zinc, while a pound of coal costing but one-thirty-sixth as much, yields 1,000,000 foot-pounds by means of the steam-engine. This lecture includes dynamos and motors, which are briefly described, and concludes with an interesting description of Hopkinson's experiments on the efficiency of dynamos and motors in the transmission of power.

In the Appendix, on the lifting-power of electro-magnets, Mr. Shelford Bidwell endeavors to show that Rowland is wrong in his statement that the greatest lifting-power was 177 pounds per square-inch. He claims that it is much greater than this.

Of errors in the book, we notice the following:

Page 13, third line "use" should evidently be "rise."

Page 21, the letters "n. s." on the little test magnets in the lower part of the figure should be reversed.

Page 23, the letters "N. S." on the horizontal solenoid should be reversed.

Page 26, eleventh line "*Fig. 14*" should read "*Fig. 15*."

Page 41, twelfth line from bottom, 3·14 should evidently be 6·28, as this is the circumference of a circle of two cm. diameter.

Page 45, tenth line, "force" should be "form."

Page 91, second and fourth lines from bottom, 3·1415 should be 6·2832.

Page 120, fifth line from bottom, "use" should evidently be "rise."

Page 121, twelfth line from bottom, "hydrostatic" should evidently be "hydrodynamic," as the former refers to water at rest.

Page 125, the first asterisk should be omitted.

Page 172, the formula might be more appropriately written $\frac{2x}{746}$, or $\frac{x}{373}$, as this is much simpler, and at the same time shows how it is deduced. On the same line, "372" should be "373." C. H.

THE THEORY AND PRACTICE OF SURVEYING. By J. B. Johnson, C. E. New York: John Wiley & Sons.

This volume of Prof. Johnson is far ahead of most treatises on surveying with which we are acquainted. There is plenty of room for improvement in this art among us. We have practised it rudely, and our text-books heretofore have been designed to meet a resulting state of things. We say rudely, where others might say with simplicity, for simplicity and rudeness are usually synonymous terms in the arts. In reality, no such quality as simplicity is in existence.

Prof. Johnson has divided his treatise into the various kinds of surveying generally practised. On land or farm surveying he says little, if anything, new, but describles fully and briefly the important points of this narrow subject. He omits those useless problems on the division of land, which encumber some other works. He treats next of topographical surveying by the transit and stadia, a method already old in Europe, but little known and less practised among us outside of Government topographical parties. It is not better than any other method; the plane table is not superseded; neither the transit, level and clinometer method; it is simply tinted, in certain cases, to give the most quickly-accurate results.

The subject of railroad surveying, we are sorry to see treated so shortly; only ten pages being devoted to it, without the aid of any illustrated examples of actual practice. The author suggests the application of the transit and stadia method to railroad work, and undoubtedly it would often prove advantageous; but we do not agree with him that its usefulness can be extended so far as to dispense with *measured* bases for the *main* preliminary lines. Hydrographic surveying is well handled. The instruction relating to it is founded upon Government practice. It includes the gauging of streams, a subject which, we must confess, we are surprised to see associated with the art of surveying.

The chapter on mining surveying has been written by Mr. A. Russell, of Colorado, and to the best of our ability to judge, appears to merit praise. It details the method of procedure in vogue in the far West. We should have been pleased to see this chapter augmented by a description of French and German practice, for in France and Germany the mines are very accurately surveyed.

The following chapter, on "City Surveying," was written by Mr. Bouton, City Surveyor of St. Louis, Mo. While an interesting chapter, it is founded exclusively on what appears to be Western practice. By combining the substance of this chapter with the instruction obtainable from the practises of such cities as Philadelphia, New York and Boston, and by illustrating the whole with some examples of city plans, we might have had a *very* valuable chapter.

Triangulation and geodetic operations are the author's strong points. He introduces the student into these subjects in an able manner; and we would advise the student to master their principles. We are upon the threshold of entering into the practice of triangulation for all accurate work, whether for line or area, following simply what has long since occurred in Europe, and will naturally take place as population becomes somewhat dense.

We might say much more upon this volume, all the contents of which we have not the space to notice, although we have read the work from beginning to end, and were altogether well pleased with it. E.

MECHANICS OF THE GIRDER. By John Davenport Crehore, C.E. New York: John Wiley & Sons.

Nearly 600 octavo pages are devoted to the calculation of bridges and roofs in this volume. Yet the mathematics employed are not difficult; the formulæ are followed in most cases by examples; the arrangement of the contents is neat and careful; the type is clear. No space is wasted in useless mathematical investigations, and everything discussed is applicable in practice. The mechanics of the girder, for all the various shapes that it assumes before the engineer, seem to have received here thorough and elegant treatment. Considerable time and conscientious work have evidently been directed toward this end.

The last chapter treats of the calculation of the weights of bridges from the strains. This is a comparatively new field of investigation. More than thirteen years ago, we deduced, to guide our practice, complete formulæ from the strains for the weight of trussed girders with parallel flanges, whatever the system of bracing, before we saw anything of value in print relating to the subject. A certain ratio, liable to little change, is required between the theoretical and actual weights of the girder, due to the extra material in connections. E.

THE CIVIL ENGINEER'S FIELD BOOK. By Edward Butts. New York: John Wiley & Sons. 1886.

The author tells us in his preface that the design of his book is to show us how to economize time and trouble in laying out railway curves. But, he illustrates his formulæ by examples, which, inconsistently with the aforesaid design, are solved by long multiplications and divisions, instead of by logarithms to five places. No well meant labor, however, is without some good attached to it. The greater portion of this little volume is devoted to an extensive table of tangent and curve-lengths for all angles of intersection from 0° to 90°, so that, if an engineer will confine himself as much as possible to whole-degree curves, such as 1°, 2°, 3°, etc., up to 10° inclusive, the table spares him the calculation of the lengths of his tangents and curve. As an example of our meaning, suppose that his angle of intersection measures 43° 21′, and that he intends to use a 2° curve; then by the table 1141·55 feet is the length of his tangents, and 2172·50 feet that of the curve, measured by 100-foot chords. E.

THE SURVEYOR'S GUIDE. By B. F. Dorr. New York: D. Van Nostrand. 1886.

How this little pocket-book came to be published by an Eastern house is a mystery. It is addressed especially to surveyors engaged on the section lands laid out by the United States Government in the West. Quite elementary in character, it is adapted to the wants of the least informed persons capable of undertaking the duties of a section surveyor. E.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, December 15, 1886.*]

HALL OF THE INSTITUTE, December 15, 1886.

CHAS. H. BANES, President, in the Chair.

Present, sixty-seven members.

Additions to membership since last meeting, eleven.

The Special Committee to "Formulate a Plan for a State Weather Service" presented a report, which appears in this impression of the JOURNAL. The report was adopted, and the committee was continued, with directions to carry the plan into effect.

The La Cour-Delany Committee reported progress.

The following nominations for officers were made, viz.:

For *President* (to serve one year), ... JOSEPH M. WILSON.
For *Vice-President* (to serve three years), ... CHAS. BULLOCK.
For *Secretary* (to serve one year), ... WM. H. WAHL.
For *Treasurer* (to serve one year), ... SAMUEL SARTAIN.
For *Auditor* (to serve three years). . . . . WM. B. COOPER.

For *Managers* (to serve three years):

CHAS. H. BANES,	WASHINGTON JONES,	A. E. OUTERBRIDGE, JR.,
C. CHABOT,	EDWARD LONGSTRETH,	THEO. D. RAND,
WM. H. GREENE,	ISAAC NORRIS, JR.,	COLEMAN SELLERS.

Nominations were then made for members of the Committee on Science and the Arts.

Dr. W. G. A. BONWILL, of Philadelphia, exhibited specimens of pure gold condensed under the blows of the electro-magnetic mallet and the mechanical mallet, and made some remarks upon the same.

The Secretary's Report was made, followed by some remarks by Prof. E. J. Houston, on "The Climatic Effects of the Removal of Forests."

The Secretary presented, on behalf of Mrs. O. H. WILLARD, of Philadelphia, a portrait of Daguérre, painted by the late Abraham Woodside. The gift was accepted, and a vote of thanks was passed to the giver.

Adjourned. WM. H. WAHL, *Secretary*.

SCIENTIFIC NOTES AND COMMENTS.

PHYSICS.

ELECTRIC BREVITIES.—As the English electricians occasionally publish articles of interest about storage batteries, it may be well to call the attention of American readers to the fact that what the English call positive and negative regarding the cell, is just the reverse of what we call them. They refer to the plates and we to the poles; both, of course, are correct. They are apparently more concerned with what takes place in the cell, while we are more interested in what the cell does in the external circuit, similarly to a dynamo, in which the Englishman's designation of positive and negative would be very confusing, to say the least. The positive pole is that attached to the negative or peroxide plate.

Advocates of wrought-iron for dynamos sometimes make some very misleading statements. In the report about an experiment with two machines of the same size, differing only in the cast- and wrought-iron in the magnets, the wrought-iron advocate says, that to generate the same number of volts the exciting current had to be more than doubled for the cast-iron magnets. This naturally leads one to suppose that cast-iron is far inferior. In another experiment, however, with the same machines, the E. M. F. was eighty and 100 volts respectively, with the same exciting current. This agrees with other data published by others, and shows in favor of cast-iron, if the price is considered. It also shows that in the first experiment the cast-iron was highly over-saturated, and that, therefore, the results of that test have no practical value for a comparison.

We are informed that an American engineer, who is an advocate of alternating currents, claims that he can charge storage batteries in the alternating current circuit. Until he can conclusively demonstrate that this can be accomplished in practice, as distinguished from a drawing or a laboratory experiment, we are justified in guarding persons against believing that the alternating current does not fail in this respect in practice. That it may be accomplished by the aid of an alternating-current motor driving a continuous-current dynamo is not new, but we presume that this is not what was meant.

Some years ago, it was remarked, jokingly, that in course of time we would be able to telephone or telegraph without the use of a wire joining the two places. Although this, at first thought, might appear impossible, yet it has actually been accomplished by a very ingenious method, invented by Prof. A. E. Dolbear. Although he described it as early as 1883, the recent issue of the patent (October 5th) brings it again before our notice. He describes it briefly as follows, in the November number of the *Electrical Engineer*: "The idea is to cause a series of electrical discharges into the earth at a given place without discharging into the earth the other terminal of the battery or induction coil. A feat which I have been told so many, many

times was impossible but which can certainly be done. An induction coil isn't amenable to Ohm's law always! Suppose that at one place there be apparatus for discharging the *positive* pole of the induction coil into the ground, say 100 times per second, then the ground will be raised to a certain potential 100 times per second. At another point let a similar apparatus discharge the *negative* pole 100 times per second, then between these two places there will be a greater difference of potential than in other directions, and a series of earth currents, 100 per second will flow from the one to the other. Any sensitive electrical device, a galvanometer or telephone, will be disturbed at the latter station by these currents, and any intermittance of them, as can be brought about by a Morse key, in the first place, will be seen or heard in the second place. The stronger the discharge that can be thus produced, the stronger will the earth currents be of course, and an insulated tin roof, is an excellent terminal for such a purpose. I have generally used my static telephone receiver in my experiments, though the magneto will answer." In conclusion, he adds that it is adapted to telegraphing between vessels at sea.

There has been considerable in both daily and technical papers lately about the system of distribution known as the Gaulard & Gibbs, in which alternating currents of high tension (!) are "converted" by an apparatus like a Rhumkorff coil into low tension currents for incandescent lighting, for which system a great saving of copper is effected. It is not very creditable to the Americans to bring before the public as new a system which has been known and used in Europe for a number of years past. If this system "revolutionizes electric lighting," it has certainly had a chance to prove its great advantages by this time. We are informed by an English electrician that the only installation in London of this system has been abandoned, and is to be replaced by another. One of the difficulties seems to be in the intense heating of the iron parts of the converters. We are told that three laboratories have been set on fire by this, in the experience of one electrician. In order to be self-regulating, the converters, it is said, have to be placed in multiple arc, and not in series, thus reducing its advantages. In this connection, it may be interesting to note that Alexander Bernstein, who, as is well known, is an American, applied for a patent for this system as early as January, 1883, which was rejected on the ground that "it is not apparent how applicant in any case can get more quantity from a secondary coil than he has in the primary." It certainly is not apparent how the Patent Office is justified in granting a patent for this same invention, in 1886, to Gaulard & Gibbs after refusing it to Bernstein. There is something wrong somewhere, and it certainly is not due to any difference in the action of the induction coil now and then.

Certain English electricians seem to be either astonishingly ignorant of what is being done in this country, or else intentionally overlook it, when they say that "at the present moment the most perfect incandescent light dynamos are produced in England. As regards arc lighters, we are in fairness bound to admit the superiority of American designs; but for incandescent lighting and for motive-power purposes we claim the lead." Then follows a statement by R. E. Crompton, showing that his machine and that

of Hopkinson (Edison remodelled) have an electrical efficiency of ninety-six per cent., which is reduced to the somewhat high inductor-velocity of fifty feet per second. If he had referred to the FRANKLIN INSTITUTE tests, he would have found that an American machine had an efficiency of 96·9 per cent. at the *lower* inductor-velocity of forty-five feet per second. Not only this, but the induction was 1·69 volts per foot in the latter at a speed of forty-eight feet per second, while those of the former were only ·66 and ·48 volts per foot at a higher speed. Even if the whole of the armature-wire is taken into consideration; that is, both the active and the inactive, our American machine still gives ·725 volts per foot at the lower speed, or ·755 at fifty feet per second. Thus, in both qualities the American incandescent light machine excels. A French machine—Raffard-Breguet, of the Gramme type—was reported to have an efficiency of seventy-eight per cent. and an induction of only ·106 volts per foot at fifty feet per second, while the current density was astonishingly high—9,240 ampères per square inch in the armature.

In a recently-published advertisement, the inventor of a motor claims as a particular advantage of his motor, that he has succeeded in diminishing the objectionable counter electro-motive force! We presume he was not joking, but it nevertheless afforded electricians amusement. We refer him to some elementary works on the subject, and for the benefit of others, we call attention to the fact that as the work consumed by a motor is C E; that is, the current × potential, and that part of this is consumed in the resistance, and is lost as heat, while the rest, represented by the current × counter E. M. F. is converted into mechanical work; therefore, the *greater* the latter the *better* the motor. C. H.

EFFECTS OF THE DESTRUCTION OF THE FORESTS.—The recent meeting of the Forestry Association in Philadelphia again calls public attention to the necessity for the enacting of laws for the better protection of our forests, and for renewal in case of their accidental or enforced removal.

The grave importance of the subject we believe will warrant the following brief *résumé* of the effects produced by the removal of the forests from a comparatively extended area. We will view these effects from the stand-point of geographical physics.

The axe of the pioneer, often taken as the symbol of a progressive civilization, unless intelligently employed, more frequently proves a bane than a blessing. The indiscriminate removal of the forests from any country necessarily produces a train of evil results both far-reaching and enduring. And yet the forest is the home of civilization, and must, therefore, make way for man.

What intelligent forestry laws should endeavor to accomplish is to ensure the continuance of certain forest areas, to prevent the indiscriminate and unnecessary removal of the trees, to avoid devastation by fires, and to provide for the replanting of areas either purposely or accidentally stripped of their forest growth.

The evil effects resulting from the removal of the forest from comparatively extended areas may be conveniently grouped under two heads, viz:

(1.) The effects produced by the removal of the vegetable covering from such areas; and

(2.) The effects produced by the subsequent removal of the soil itself by the action of water on the bare earth.

The evil effects caused by the removal of the vegetable covering from any section of country may be arranged under two general heads, viz.: First. Climatic changes; and second, Changes in the distribution of the precipitation.

(1.) *Climatic Changes.*—The bare, unprotected earth, no longer shielded by its vegetable covering, both heats and cools rapidly. There thus result great extremes of temperature. The air over the denuded area is intensely hot in summer, and very cold in winter. The soil is baked and parched in summer, and frozen to a much greater depth and at an earlier date in winter.

When such area is of sufficient extent, the climatic changes thus caused cannot fail to be marked and far-reaching.

(2.) *Changes in the Distribution of the Precipitation.*—When the forests are removed, the rain instead of sinking deep into the ground, and filling the reservoirs of springs, drains rapidly off the surface into the river channels, thus increasing the frequency and severity of inundations. When the ground is covered with trees or other vegetation, the rain sinks quietly into the earth along the trunks or stems, or is retarded by the undergrowth for a sufficient length of time to permit it to sink directly into the earth.

Rapid surface drainage and consequent inundations are especially apt to occur in the early spring, when the ice and snow melt along the river courses. This is due to the fact that if the first snow of the season should occur after the first severe frost, which is nearly always the case, it falls on the bare, unprotected, and consequently deeply-frozen ground. On melting in early spring, it cannot sink into the still frozen earth, and therefore drains rapidly off the surface. When, on the contrary, the forest still remains, the winter's first snow falls generally on the unfrozen earth and keeps it from freezing thereafter.

The rapid surface drainage thus effected by the destruction of the forest brings a train of evil effects, both on the uplands and the lowlands. The water drained directly into river channels not only brings disastrous inundations to the low-lands, but being lost to the reservoirs of the upland springs, causes them either to dry up, or to become limited in their discharge on the first approach of drought. The surplusage of water that occurs during the inundations of the rivers is necessarily followed by a marked deficit during even comparatively dry weather. The rain-fall, instead of reaching the rivers indirectly, through the discharge of springs, in perhaps several weeks, is rapidly drained therein, directly, in a few days.

It is this circumstance which has most probably led to the popular belief that the destruction of the forests produces a direct influence on the amount and frequency of the rain-fall in the denuded districts. Though it cannot be denied that the removal of the forests from a very extented area, must to some extent influence the rain-fall of the country, yet it is evident that

such influence is rather that above pointed out; viz., an effect on the distribution of the rain-fall in its time of drainage into the river channels, rather than on the distribution in point of either frequency or quantity.

Let us now consider the nature of the effects produced by the removal of the soil from the uncovered earth, consequent on the rapid drainage of its surface.

The vegetable mould, or soil of any section of country, is a result of gradual accumulation or formation, not only by the disintegration of the primitive rocks or earth, but also by its continuous enrichment from the gradual decay of pre-existing races of plants. Given the climatic conditions of light, heat and moisture, a soil will gradually be evolved, even from bare rock, but its evolution is a matter of comparatively extended time. It is therefore an almost fatal loss to the uplands, to have them denuded more or less completely of their virgin soil, by the rapid surface drainage that necessarily follows the indiscriminate removal of the forests.

The evil, however, does not stop here; not only are uplands impoverished by the removal of their virgin soil, but the silt, thrown into the river channels, accumulates in sand-bars, or flats in the channels, or in the mouths of rivers, thus proving a serious impediment to inland navigation; or, spread over the alluvial flats in the lower courses of the river, brings contagion and death to the adjoining districts.

Besides the evils above pointed out, which, as will be seen affect nearly all parts of the river basin, the uplands as well as the lowlands, there are two other evils that have not as yet been generally recognized, viz.: hail-storms and tornadoes.

There can be but little doubt that the sudden and extreme changes of temperature that are caused by the removal of the forests over extended areas, produce meteorological conditions, favorable to the existence of hail-storms and tornadoes. That both of these destructive meteors are especially prevalent in the neighborhood of districts from which the forests have been removed, statistics will show; neither can occur without great differences of temperature, and such differences are the necessary concomitants of denuded areas.

The necessity for intelligent legislation for the better protection of the forests is apparent. We trust therefore that the the American Forestry Association will continue in their good work. E. J. H.

BULLETIN OF THE UNITED STATES GEOLOGICAL SURVEY, NO. 31.—MINERAL SPRINGS OF THE UNITED STATES.—Dr. Albert C. Peale, of the United States Geological Survey, has made an admirable compilation of the mineral springs of the United States, that, besides being of value to the geological world, cannot fail to prove of considerable interest to the medical profession.

In this publication of the *United States Geological Survey*, Dr. Peale has made a very complete classification of nearly all the known mineral springs of the United States. The springs are arranged in the following groups, viz: The Northern Atlantic States, the Southern Altantic States, the Southern Central States, the Northern Central States, and the Western States and Territories.

Besides a general description of the more noted mineral springs, there are given reliable chemical analyses of the various waters. This feature cannot fail to be of value to the medical profession.

The completeness of the classification may be judged from the fact that it includes some 2,822 localities.

Speaking of the definition to be attached to the word "mineral water," the author justly remarks that such definition must necessarily vary according as to whether the subject be viewed from the standpoint of the geologist, or from that of the physician. On the one hand, water is itself a mineral, and is seldom found absolutely pure in its natural state. On the other hand, from a therapeutic standpoint, any water that has an effect on the animal body, from the mineral substances it contains, is a mineral water, no matter how small the percentage of such mineral matter. Generally speaking, however, mineral waters are such as are characterized by an unusual proportion of mineral matter, or whose temperature is considerably above the normal, in which case the percentage of mineral ingredients is almost necessarily high.

Without going into a special classification of mineral waters, the author gives the following general divisions:

(1.) As regards their temperature as thermal or non-thermal.

(2.) As regards the presence of certain dissolved gaseous substances, as carbonated, sulphuretted, or carburetted, etc., waters.

(3.) As regards the mineral ingredients proper, as chalybeate, alkaline, saline, calcic, silicious, or acid, named from the predominant or characteristic solid constituents.

The book is furnished with a valuable, because unusually complete, index of the various localities. E. J. H.

APPLICATION OF ELECTRICITY TO WEAVING.—A manufacturer of Roubaix, M. Henry Buisini, has just discovered a very curious application of electricity to looms. He adopts an indicator which strikes when a thread in the warp breaks, and thus saves the warper from taking out any of his work to find the flaw, and he need not pay such close attention to the quickly moving threads which is so injurious to the sight. The invention can be applied to power-looms.—*Chron. Industr., Sept. 19, 1886.* C.

CHEMISTRY.

ON THE VAPOR-PRESSURES OF BROMIDE AND IODINE, AND ON IODINE-MONOCHLORIDE. By W. Ramsay and S. Young (*Jour. Chem. Soc.* **49,** 453).—The authors have here applied the results of their numerous observations upon vapor-pressures, to the determination of the melting-points of bromine and iodine, and also of the boiling-point of bromine. The method employed is that described by the authors (*Jour. Chem. Soc.* **47,** 42). Every precaution was taken to insure the purity of the substances. In the case of bromine, as well as of iodine, the curve expressing the relation of pressure to temperature for the solid substance is not a continuation of that for the liquid, but they intersect. For bromine, the curves intersect in a point corresponding to a temperature of 7°·1 and a

pressure of 44·5 mm.; while in the case of iodine, the curves intersect at 114°·3 and pressure 91 mm. It has been proved by the authors that for a number of substances the point of intersection of these two curves corresponds to the melting-point. From the combined data, of direct observation, of the intersections of the vapor-pressure curves, and of the intersection of the lines for the ratios of the absolute temperatures at constant pressure of bromine to water, of iodine to water, and of bromine to iodine, that the correct values for the melting-points are: bromine, — 7°·05; iodine, 114°·15. Boiling-point of bromine, 58°·7, which agrees closely with previous observations. A. G. P.

SARDINE OIL.—Two years ago a substance of the consistency of butter, and of an insupportable odor, was introduced from Japan into Europe. It was made from a particular kind of sardines and contained twenty-five per cent. of solid, fatty matter to seventy-five per cent. liquid oil. This oil is now refined at Yokohama and exported in three grades, the coarsest being known as fish-tallow or fish-stearine. Its production is also enormous in Cambodia, Tonquin, Annam and Cochin, China. M. Villon, of Lyons, has analyzed sardine-fat and finds that it contains:

Water,	5·52
Oleine,	57·18
Margarine and stearine,	35·11
Free oleic acid,	1·50
Iodine,	0·1
Organic remains,	0·2
	99·61

The industrial applications of this new product are only in an experimental stage, but M. Villon thinks that pure or in combination it may render great service to leather dressers and to soap and stearine workers. It can also be used in lubrication.—*Chron. Industr., Sept. 19, 1886.* C.

FUSTIN, OR THE GLUCOSIDE OF FISETIN.—This compound is prepared from the above fustin tannide by treatment with acetic acid and crystallizing from hot water. It occurs in yellowish-white, silvery needles, melting at 200°, and dissolving easily in warm water, alcohol and dilute alkalies, but sparingly soluble in ether. H. T.

ON ESSENTIAL-OILS. PART III. THEIR SPECIFIC, REFRACTIVE AND DISPERSIVE ENERGY. By J. H. Gladstone (*Jour. Chem. Soc.*, **49**, 609).—In this paper, the author brings forward the arguments founded on the phenomena of dispersion and refraction, which throw light upon the question as to the number of doubly-linked carbon-atoms present in those hydro-carbons known as essential-oils. The following definitions are given: The specific refractive energy of a substance is its refractive index minus unity divided by its density, and, calculated for the line *A* of the solar spectrum, is represented by the formula, $\frac{\mu A - 1}{d}$. The specific dispersive energy is the difference between the specific refractive energies of the two extreme visible lines *A* and *H*; *i. e.*, $\frac{\mu H - \mu A}{d}$. The foregoing expressions multiplied by

the atomic weight, give what are termed, respectively, the refraction and dispersion equivalents; *i. e.*, $P\frac{\mu A - 1}{d}$, and $P\frac{\mu H - \mu A}{d}$. In all saturated compounds, the refraction equivalent of one atom of carbon is found to be 5·0 for the line *A*, and that of hydrogen 1·3. It has long been known that more than thirty of the essential-oils which have been examined, give refraction equivalents a little above the theory. Subsequently, Brühl showed that in case of "double-linkage," each such carbon-atom has a refraction equivalent about 6·1, or, each pair increases the normal equivalent about 2·2.

Among saturated organic compounds, the author has found the dispersion equivalent of CH_2 to be 0·342. The "double-linkage" of a pair of carbon-atoms tends to increase the dispersion equivalent.

The main results of the investigation will be found in the following table. That theory is expressed in Column 4, which contains the number of pairs of carbon-atoms taken to be "double-linked," on the basis of each substance containing ten atoms of carbon. Whether, in fact, it is C_{10}, or C_{15}, or C_5, is not indicated by these optical properties.

Hydrocarbon.	Experimental.		Pairs of C Doubly-Linked.	Theoretical.	
	Specific Refractive Energy.	Specific Dispersive Energy.		Specific Refractive Energy.	Specific Dispersive Energy.
Cymhydrene,	0·543	0·0246	None.	0·543	0·0243
Menthene,	0·548	0·0313	1	0·547	0·0298
The terpenes,	0·537	0·0295	1	0·537	0·0296
Terebathene,	0·537	0·0294	1	0·537	0·0296
Camphene,	0·528	0·0269	1	0·537	0·0296
The cedrenes,	0·538	0·0296	1	0·537	0·0296
The citrenes,	0·551	0·0334	2	0·553	0·0354
Isoterebenthene,	0·552	0·0317	2	0·553	0·0354
Caoutchene,	0·554	0·0366	2	0·553	0·0354
Cymene,	0·560	0·0406	3	0·558	0·0413
Isoprene,	0·592	0·0470	4	0·585	0·0472

A. G. P.

Separation and Properties of Germanium.—C. Winkler has published (*Journ. für Prakt. Chemie.*, **34**, page 177,) the following as the best method for the separation of germanium. Finely-powdered argyrodite is fused with a mixture of equal parts of sulphur and sodium hydroxide at a dull red heat in a Hessian crucible. The pasty mass is poured into a heated iron mortar and pulverized after cooling; the powder is exhausted with boiling water, and the residue is again fused with sulphur and sodium hydroxide. The solution obtained is exactly neutralized with sulphuric acid and allowed to stand twenty-four hours, in which time sulphur deposits, carrying with it the sulphides of arsenic and antimony, while the germanium remains dissolved in the opalescent liquid. This liquid is decanted, mixed with an

excess of hydrochloric acid, and saturated with hydrogen sulphide. In the course of a day, a voluminous white precipitate of germanium sulphide separates; this is washed with water saturated with hydrogen sulphide, and containing one-fourth its volume of hydrochloric acid, and the washing is concluded with ninety per cent. alcohol saturated with hydrogen sulphide.

The germanium sulphide so obtained is roasted at a low temperature and then heated with nitric acid. On calcining the residue, an oxide is formed that may be reduced in a current of hydrogen, and the pulverulent germanium thus produced is sufficiently pure to serve for the preparation of its compounds.

The best flux for fusing the element, which melts at about 900° C., is borax, and by slowly cooling the molten mass the germanium may be obtained in fine, regular octohedra, having a bright metallic lustre and a grayish color.

The density of germanium at 20°·4 C. is 5·469. Its atomic weight, determined by analysis of the chloride, $G_2 Cl_4$, is 72·32. It is not attacked by hydrochloric acid. Nitric acid and nitro-hydrochloric acid convert it into a white oxide. By the aid of heat, sulphuric acid converts it into a soluble sulphate. It forms explosive mixtures with the chlorates and nitrates.

W. H. G.

The Most Rational Division of a Set of Weights.—J. D. Van de Plaats (*Receuil des Travaux Chimiques des Pays Bas*, **5**, 215), gives the results of calculations as to the best set of weights for the various uses of a chemist. The two principal objects of weights are (A) the determination of the mass of any given substance; (B) the separation of a given mass of any substance. The requirements of a set of weights are: (1.) That the number of weights be as small as possible; (2) that the operations A and B may be performed in the least possible time; (3) that the different weights may be placed on the same pan of the balance; besides this, it is desirable (4) that the weights may be readily comparable among themselves; (5) that there shall not be two weights of the same value. As a general conclusion, the author considers that the most desirable weights for a chemist would be of values in the system 1, 2, 3, 5. W. H. G.

On the Preparation of Formaldehyde.—B. Tollins (*Berliner Berichte*, **19**, 2135), publishes as the best method for the preparation of formaldehyde, the aspiration of air through methyl alcohol heated to 45°–50° C., in a water bath, then through a tube containing copper gauze heated to the softening point of Bohemian glass; the glass tube containing the gauze must be supported by wrappings of copper gauze or foil. In this manner a few litres of thirty or forty per cent. formaldehyde solution may be prepared in a short time, and hundreds of grammes of oxymethylene may be readily obtained.

W. H. G.

A New Method for Obtaining the Specific Gravity of Easily Soluble Substances.—L. Zehnder describes (*Ann. Phys. Chem.*, **29**, 249), a method which is equally applicable to insoluble substances. The pyknometer for solid substances is employed, and after the weight of the

instrument and solid has been found, the pyknometer is inverted in distilled water: the solid falls out, and is, of course, replaced by an equal volume of water, whose weight is then determined. Figures are given, showing that the method is trustworthy. W. H. G.

A SURE METHOD OF CUTTING GLASS TUBES.—Ernest Beckmann (*loc. cit.* 530), states that glass tubes of any thickness and diameter, as well as funnels, bell-jars, etc., may be safely cut by making a file mark and then building up rings of wet filter paper, 1–2 mm. high, and 2–4 mm. wide on each side of the mark, at a distance of 1–2 mm. The intervening space is then heated in a Bunsen burner flame, or better, by the pointed flame of a blast-lamp, while the tube is rotated on its axis. The tube then separates at once in the line between the walls of filter paper. The paper must be saturated with water, must be evenly laid on, so that it builds up straight walls, and the thickness to which it is wrapped will depend upon the diameter and thickness of the tube. W. H. G.

NOTES ON RUSSIAN PETROLEUM.—Prof. C. Engler, of the Polytechnic School at Carlsruhe, Germany, has recently published (*Ding. Jour.*, **260**, pp. 337, *et seq.*) a lengthy account of a visit he paid to Baku and the Russian oil-fields in the fall of 1885, and taken the opportunity to collate much of historical and statistical interest with regard to this industry.

The first production of burning-oils from this field was about 1855, and strange to say was not from the naphtha or crude oils already abundantly found at that time, but was from a solid material resembling ozokerite, and known as "kirr." Application having been made to the great German chemist Liebig, he sent an assistant of his, Moldenhauer, who erected the first refinery and soon abandoned the "kirr," which yielded only fifteen to twenty per cent. of a heavy oil, and began the distillation of the crude naphtha. He left in 1860, and was succeeded by Eichler, who is still engaged in the work at Baku.

The production of crude oil for the last ten years, reckoned in barrels, for comparison with American production, is as follows:

	Barrels.		*Barrels.*
1876,	1,385,714	1881,	3,500,000
1877,	1,728,571	1882,	4,857,142
1878,	2,285,714	1883,	5,714,285
1879,	2,642,857	1884,	8,071,428
1880,	3,000,000	1885,	11,685,714

The price of the crude oil, which in 1872 was still $2.45 per barrel, dropped in 1877 to forty-two cents per barrel, and to-day ranges from fourteen to twenty-one cents per barrel.

The production of refined burning-oil in Baku for the year 1885 was 3,214,285 barrels, of lubricating-oil, 185,714 barrels, and of residues, 3,642,857 barrels.

It will be interesting to compare these figures with the present production and export of American petroleum. According to Stowell's *Petroleum Reporter*, the production of crude oil for the year 1885 was 20,776,165 barrels, and the amount of refined burning-oil exported to Europe was 11,428,571 barrels.

The flowing-wells of the Baku district, in the energy with which they throw out the oil and the quantity so projected, far exceed even our largest American "spouters." In 1883, three such powerful oil fountains were opened, viz.: the Lianozoff, the Drujba (pronounced Druschba), belonging to an American company, and the Nobel Brothers, No. 9. The Lianozoff, the first opened, threw a stream of oil 200 feet high, while the Drujba well gave a stream that at times rose to 300 feet, and yielded some 57,143 barrels of crude oil daily, an amount more than eight times that of the Armstrong Well, No. 2, struck in 1884, in Butler County, Pa., and considered the greatest flowing-well of the Pennsylvania oil-field. The Nobel Brothers No. 9 fully equalled the Drujba, and is said to have yielded 800,000 barrels of oil in four weeks' time.

The depth of these yielding wells is much less than those of the American oil-fields, the average depth of the wells, in 1885, being 482 feet.

The advent of the firm of Nobel Brothers, in 1875, gave a great impulse to the production, refining and handling of the petroleum of this district. They particularly improved the transportation and delivery methods for all the products, introduced pipe-lines, oil-tank cars and oil-tank steamers on the Volga and the Caspian Sea, and experimented upon the proper utilization of the large amounts of residues that remained, in the preparation of burning and lubricating-oils.

It is well-known that the Russian petroleum differs from the Pennsylvanian in its specific gravity, being distinctly higher in most cases. This is explained when we compare the distillation results. Thus, according to Engler, the following results are gotten with the oil from the two main localities:

	Balakhani.	*Bibiybat.*
Volatile-oils (benzene, etc.),	5 to 6 per cent.	20·5 per cent.
Illuminating-oil I (kerosene),	27 to 33 "	40 "
Illuminating-oil II (solar-oil),	5 to 6 "	13·5 "
Residues,	50 to 60 "	36 "

This shows a relatively small percentage of illuminating-oil as compared with the Pennsylvanian and other crude oils, as will be seen from the following table:

	Pennsylvanian.	*Galician.*	*Roumanian.*	*Alsacian*
Volatile-oils,	10 to 20 per cent.	3 to 6 per cent.	4 per cent.	. . . . .
Illuminating-oil,	60 to 75 "	55 to 65 "	60 to 70 "	35 to 40 per cent.
Residues,	5 to 10 "	30 to 40 "	25 to 35 "	55 to 60 "

Of course, the residues from the Baku refineries can be made to yield most valuable lubricating-oils.

Interesting statements as to the character of the residues and as to methods of distillation, etc., will have to be deferred for another abstract.

S. P. S.

ON A LITTLE KNOWN CAUSE OF CORROSION OF STEAM GENERATORS. M. M. Klein and Berg, (*Comptes Rendus*, **102**, 1170.)—It often happens in sugar refineries, where syrups are evaporated in a vacuum by means of steam coils, that in consequence of defects in the apparatus some sugar is introduced into the boilers.

Whenever there is molasses containing acid products, especially butyric

acid, corrosion is naturally looked for, but it has been generally supposed that pure syrups are nearly or quite inoffensive. Experiments have been made with cane-sugar, grape-sugar, maltose, glycerine and mannite dissolved in water in known proportions. The solution of these different substances was heated in sealed tubes at a temperature of 115° to 120°, and the action upon iron determined in two ways: (1.) By inserting iron in the liquid; (2.) by the diminution in weight of the tubes themselves. For comparison in each experiment, iron tubes containing distilled water were heated, which gave no solution of iron, but simply insoluble sesqui-oxides more or less hydrated in small quantities. In every instance, the sweetened liquids which were heated in contact with iron, gave a marked acid reaction. The liquid took an amber color with a greenish tinge, contained a notable proportion of iron and held in suspension mica-like flakes, formed of a substance analogous to the ill-defined bodies which have been extracted from caramel, containing evident traces of iron. At the same time considerable hydrogen was set free. Other things being equal, the quantity of iron dissolved increases in proportion to the amount of sugar in the solution; the iron was in the form of acetate. Glycerine and mannite appeared to have no action upon the iron. Zinc is strongly attacked by sugar with an abundant production of hydrogen; there is no caramel formed and the acid does not appear to be acetic. Copper, tin, lead, aluminium and cadmium do not appear to be attacked.

C.

THE COLORING MATTER OF YOUNG FUSTIC. J. Schmidt. (*Berlin Ber.*, **10**, p. 1734.)—Fisetin, the yellow coloring matter of young fustic (*Rhus cotinus L.*), has already been investigated by Chevreul and others, and was supposed to be closely related to, or identical with, quercetin.

The author shows that fisetin is not identical with quercetin, but that it occurs as a glucoside (fustin) in combination with tannic acid (fustin tannide).

H. T.

FUSTIN TANNIDE, OR GLUCOSIDE TANNIC ACID OF FISETIN.—Rasped young fustic is extracted with boiling water, the solution purified by the addition of a small quantity of acetic acid and lead acetate. The lead is removed by H_2S, and the tannic acid precipitated by common salt. The filtrate is shaken with acetic ether, which takes up the tannide and leaves it in yellowish, impure crystals on evaporation. H. T.

FISETIN (C_{23}, H_{10}, O_3 $(OH)_6$.—This dye, which results from the decomposition of the above glucoside, is best prepared by extraction with alcohol from the solid extract which comes in commerce under the name of "cotinin." The impurities are removed by acetic acid and lead acetate, and, after the removal of the lead by H_2S, the dye-stuff is precipitated by the addition of hot water. It is purified by recrystallization from dilute alcohol or acetic acid. The alcoholic solution of fisetin shows the following reactions: Lead acetate, a brilliant orange red precipitate; stannous chloride, an orange yellow precipitate, and acetate of copper, a brown precipitate. Concentrated acids or ammonia give the solution a reddish, yellow color. It reduces Fehling's solution on warming. H. T.

THE "NOVELTIES" EXHIBITION OF THE FRANKLIN INSTITUTE, 1885.

ABSTRACTS OF REPORTS OF THE JUDGES.

(*Continued from Vol. CXXII, page 480.*)

GROUP 12*a*.—GAS MANUFACTURE FOR ILLUMINATING AND HEATING, AND APPARATUS THEREFOR, INCLUDING COAL- AND OIL-GAS AND NATURAL-GAS APPLIANCES.

Judges:—Griffith M. Eldridge, Wm. H. Greene, L. B. Hall, Wm. D. Marks, G. M. Ward, Moses G. Wilder, Wm. H. Wahl, *Chm.*

LOWE MANUFACTURING CO., NORRISTOWN, PA.

Water-Gas and Applications thereof.—The exhibit of this company formed a very complete exposition of the capabilities of water-gas for heating, lighting and the generation of power. It embraced a gas-works, complete for the generation of water-gas, having a capacity of 5,000 cubic feet per hour.

The adaptability of the product as a fuel was exhibited in a variety of ways. It was used exclusively in the restaurant for all the uses in cooking, baking, etc., for which solid fuel is commonly used, and by various exhibitors throughout the Exhibition for heating, baking, driving gas engines, and other special uses.

For the utilization of gas for fuel purposes, the company exhibited a variety of ovens, cooking ranges, open-fire stoves, heaters, etc., of special designs.

In a suite of three rooms, occupied by this company, a very attractive display was made of the adaptability of water-gas for domestic lighting and heating. Its display embraced an open fire-place of the usual pattern, various forms of fixtures adapted for a special system of incandescent lighting (which will be treated of later), several forms of combined heating, lighting and ventilating devices, etc., etc.

The general purpose of these exhibitors was to show how, through a single line of pipe laid in the streets of cities and towns, a gas may be distributed, which will serve as an efficient and economical source from which light, heat and power may be obtained. In respect to the variety of applications shown, and the ingenuity displayed in the design of the various devices used, and the mechanical skill and tastefulness exhibited in the construction the exhibit of the company was highly commendable.

Taken collectively, it is safe to say, that, in respect to completeness and variety, it far surpassed any exposition of the capabilities of water-gas ever before attempted.

The time at the disposal of the judges has not been sufficient to enable them to make a careful examination of the question of originality in connection with many features of this interesting exhibit.

Water-gas made by the interaction of steam and carbon at a high temperature, and composed essentially of hydrogen and carbonic oxide, has been known and employed for many years. It is only, however, of late years, that the difficulties in the way of its successful commercial introduction have been practically overcome.

Generally, the improvements that have brought about this result consist of the adoption of methods, whereby the waste of heat in the various steps of the manufacture is reduced to the minimum.

The principal portion of this waste was, formerly, the large consumption of coal required for heating the contents of the generator to the proper temperature to effect the decomposition of the steam, the heat required for the production of the steam, and the heat carried off by the water-gas after its formation.

These elements of waste have been largely reduced by the adoption of devices, whereby the products of incomplete combustion in the generator are regenerated, and caused to impart the heat derived from their subsequent combustion to such heat-storing materials, as fire-brick, etc., suitably placed in a regenerative chamber, or superheater, forming the upper portion of the generator, or connected with it, and through which the steam is caused to pass on its way to the generator.

Further, by using other portions of the waste heat, to heat the air used for blowing up the charge of coal in the generator, and to generate the steam required in the process. By these and other improvements in the construction of the apparatus employed, and in the details of the operation, the quality and quantity of water-gas produced from a ton of coal have been, respectively, considerably increased and improved, and the cost of its production so notably reduced that the problem of introducing it as a fuel for domestic and industrial purposes can no longer be considered as visionary.

It is proper to state in this place, that, with a number of the improvements above noted, and which have substantially con-

tributed to the practical success of water-gas manufacture, the name of THADDEUS S. C. LOWE, of Norristown, is honorably associated, and a number of patents embodying the same have been issued to him, which are accessible for reference.

The devices in the form of ovens, heaters, ranges, stoves, etc., which are embraced in the exhibit of the Lowe Manufacturing Company, are in great variety, and are admirably adapted to serve their intended purposes.

On the general question of the desirability of gaseous fuel, there can be but one opinion. It dispenses with the trouble and annoyance of hauling and carrying coal, and with the removal of dirt and ashes; it is at all times under perfect control; when not wanted it can instantly be extinguished and can instantly be made to give its maximum effect, so that, other things being equal, gaseous fuel possesses incontestable advantages over solid fuel.

Respecting the availability of water-gas for this purpose on the score of economy, the Lowe Manufacturing Company claims to produce from a ton of coal 80,000 cubic feet of water-gas, at a cost of less than ten cents per 1,000. At these figures, twenty-eight pounds of anthracite coal would yield 1,000 cubic feet.

The specific gravity of the Lowe Fuel-Gas, as determined by Dr. Ward, of the judges, is (at 62° F.) ·552 (air = 1).

The 1,000 cubic feet would, therefore, weigh 42·01 pounds. As the theoretical yield of 100 pounds of pure anthracite would be 228·22 pounds of pure gaseous products, the figures claimed to be obtained by the Lowe Manufacturing Company, would be sixty-six and two-thirds per cent. of the theoretical yield of pure carbon. This would leave but thirty-three and one-third per cent. to provide for the consumption of coal for heating the generator, for the production of steam, and the impurities of the coal.

The judges had no opportunity to actually test the question by experiment, but they feel satisfied that the company's estimate of production is too high.

In processes analogous to this in general principles, a practical yield of from 40,000 to 45,000 cubic feet has been obtained, and the judges assume the smaller quantity here named as the safer one to proceed from.

Dr. Greene, of the judges, made an analysis of the gas, taken on October 19th, with the following results:

	By Volume.	*By Weight.*
CO_2,	3·6	9·3
CO,	42·1	69·3
H,	44·5	5·2
N (by diff.),	9·8	16·2
	100·00	100·00

The theoretical calorific equivalent is:

	Composition in Dec. of one Pound.		*Calor. Equiv.*
Nitrogen,	0·162	×	0·0
Carbonic acid,	0·093	×	0·0
Carbonic oxide,	0·693	×	4325·4 = 2997·4
Hydrogen,	0·052	×	62031·6 = 3225·7
Calorific equivalent of Lowe gas in British heat units,			= 6223·1

Taking the yield of gas to be 40,000 cubic feet per ton of coal (2,240 pounds), fifty-six pounds would be sufficient to yield 1,000 cubic feet of gas, weighing, as above noted, 42·01 pounds, and having a theoretical heating effect of $(42{\cdot}01 \times 6223{\cdot}1) = 261{,}433$ units of heat.

As, in the combustion of gaseous fuel, under favorable circumstances, the only loss is from radiation, it is fair to assume that this loss will not exceed ten per cent. This will leave of the above, 235,289 units realizable in practice.

Fifty-six pounds of coal would have a theoretical heating effect of $56 \times 14{,}544 = 814{,}464$ units, of which about fifty per cent. may be assumed to be realizable.

This would leave, under ordinary circumstances, 407,232 units available in practice; from which it appears, under the ordinary conditions of practice, the fuel-gas will produce fifty-three per cent. of the available heating effect of the coal used in making it.

The company states that the cost of production will be less than ten cents per 1,000 cubic feet. We will take ten cents. Taking pea coal at $1.50 per ton, the fifty-six pounds will cost three and three-fourths cents, and, with the assumption of only fifty per cent. of the theoretical effect yielded, the figures would be doubled. When, therefore, solid fuel is utilized, as in ordinary steam generation, the relative cost of coal, and of the fuel-gas which may be obtained from it, under the above assumptions of cost, will be in favor of coal.

This, however, is the conclusion from assumptions, which present the most unfavorable conditions for fuel-gas. For, in practice, the

cheapest grades of coal cannot be used, and the cost of coal generally used for manufacturing and domestic purposes, may be assumed to be $4.50 per ton, which would make the cost of the fifty-six pounds (above employed) equal to eleven and one-quarter cents, which, when compared with the figure of ten cents, which we have purposely taken for the Lowe Fuel-Gas, shows that the fuel-gas can compete economically with solid fuel, where the cost of distribution is neglected.

We should state here in justice to these exhibitors, that they claim to be able to produce fuel-gas considerably cheaper than ten cents per 1,000 feet.

In all the above calculations and comparisons, it should be noted that the judges have presented the case of fuel-gas in the most unfavorable light, so that the conclusions above announced may be considered as an exhibit of the lowest economical results that should be attained in practice. For, it should be stated, that in ordinary practice, especially for domestic service, very much less than fifty per cent of its thermal value, is obtained from the combustion of coal.

As, under these unfavorable assumptions, the results obtained exhibit a comparative economy in favor of fuel-gas, the friends of water-gas have every reason to be satisfied.

Much stress has been laid by certain writers upon the poisonous effects of water-gas, due to the large percentage of carbon monoxide, which it contains, and which is held to constitute a serious objection to its general introduction. This objection, the judges do not deem sufficient to warrant the condemnation of an agent which promises to serve so many useful purposes. The same objection was made to coal-gas, by those who opposed its first introduction, and with as much justification as the opponents of water-gas have at the present.

For the purpose of asphyxiation, either coal-gas or water-gas, will answer quite satisfactorily. It should be remembered, however, that neither of these agents is intended to be breathed, and that the safeguards surrounding the distribution of gases are so perfect that accidents from accidental leakage are of the rarest occurrence.

It is also easy to perfume the gas by slight additions of hydrocarbons, so that $\frac{1}{10,000}$ of one per cent. may be detected by the sense of smell.

While, therefore, it is undoubtedly true that the toxic effects of water-gas are more decided than those of common coal-gas, the judges, in view of the facts above named, do not believe that this constitutes an objection of sufficient weight to warrant the condemnation which some alarmists have cast upon it.

The judges are unanimous in the opinion that the display of the capabilities of water-gas for fuel purposes, made by the Lowe Manufacturing Company, was a most instructive and creditable one.

CARBURETTED WATER-GAS.

The carburetted water-gas was made simply by allowing the gas from the gas holder to pass through the carburetter, and saturate itself mechanically with the gasolene vapor. In this condition it was used principally by the Siemens-Lungren Gas Light Company for lighting a portion of the main avenues. The judges submitted the gas to photometric examinations, with the following results:

PHOTOMETRIC RECORD.

(*Observers: Greene, Marks, Wahl and Ward.*)

Gas consumption per hour,	3·9 cubic feet.
Ignition pressure,	0·15 inches.
Burner U. S. Standard.	
Illuminating value,	18·33 candles.
Equivalent candle-power, at five feet consumption,	23·50 candles.
Candles per cubic foot,	4·7

THE LOWE INCANDESCENT GAS LIGHT.

This light is obtained by allowing the non-luminous water-gas to impinge upon a spiral wire of platinum or platin-iridium. Several forms of this burner are used. Those shown at the Exhibition and examined by the judges were formed of a stout wire of horse-shoe shape, the ends of which were attached to a brass collar, and fitted snugly upon the ordinary lava-tip slit burner. Upon this stout wire there was tied by means of a fine wire of the same material a close spiral of platinum, or platin-iridium, the stout supporting wire being placed on the upper or outer surface of the curve formed by the spiral. The size of the horse-shoe varies with the size of the burner on which it is intended to be used.

They were shown singly, or in groups, or clusters, upon chandeliers of the ordinary pattern, and upon specially designed fixtures, in several of the avenues and in the tastefully decorated rooms occupied by the Lowe Manufacturing Company.

The adjustment of the spiral is such that the flame of the gas shall surround it, so that every part thereof may be equally heated by it. To do this properly requires that the alignment of the spiral with respect to the flame shall be perfect, and that the orifice from which the flame issues shall be kept free from dust or other obstruction, otherwise the unequal brightness of the spiral becomes at once apparent.

Observations of these lights at the Exhibition and at the company's works, at Norristown, warrant the judges in the belief that these requirements present no serious difficulties in practice. When the gas is lighted, the spiral at once becomes brightly luminous, affording a steady uniform light, which at first suggests to the observer the well-known incandescent electric light.

The judges have no data upon which to estimate the average life-duration of these burners, the opportunity for such tests as would be required to determine this question, not having presented itself. It may be proper to state, however, that the Lowe Manufacturing Company claims to have had 2,000 hours of service from experimental burners of this type, without appreciable deterioration.

It is alleged, likewise, that the question of durability is of secondary importance, since when spirals cease to act satisfactorily from any cause, they will still be worth the weight of the metal they contain, and may be exchanged for new spirals at a fractional cost above that of the metal.

The results of photometric tests of a series of these spirals, using Lowe Fuel-Gas, manufactured on the exposition grounds are given herewith:

PHOTOMETRIC RESULTS.

(*1.—Observers: Marks, Wahl and Ward.*)

Gas consumption per hour,	9·69 cubic feet.
Ignition pressure,	2·25 inches.
Illuminating value,	12·85 candles.

Equivalent to 1·33 candles per cubic foot.

(*2.—Observers: Wahl and Ward.*)

Gas consumption per hour,	8·31 cubic feet.
Ignition pressure,	2·37 inches.
Illuminating value,	10·88 candles.

Equivalent to 1·31 candles per cubic foot.

(*3.—Observers: Wahl and Ward.*)

Gas consumption per hour,	7·9 cubic feet.
Ignition pressure,	2·5 inches.
Illuminating value,	12·24 candles.

Equivalent to 1·55 candles per cubic foot.

(*4.—Observers: Wahl and Ward.*)

Gas consumption per hour,	6·7 cubic feet.
Ignition pressure,	1·75 inches.
Illuminating value,	8·48 candles.

Equivalent to 1·26 candles per cubic foot.

(*5.—Observers: Wahl and Ward.*)

Gas consumption per hour,	6·7 cubic feet.
Ignition pressure,	1· inch.
Illuminating value,	8·41 candles.

Equivalent to 1·25 candles per cubic foot.

(*6.—Observers: Wahl and Ward.*)

Gas consumption per hour,	5·58 cubic feet.
Ignition pressure,	3·25 inches.
Illuminating value,	9·94 candles.

Equivalent to 1·78 candles per cubic foot.

(*7.—Observers: Wahl and Ward.*)

Gas consumption per hour,	5·1 cubic feet.
Ignition pressure,	1·5 inches.
Illuminating value,	6·85 candles.

Equivalent to 1·34 candles per cubic foot.

(*8.—Observers: Wahl and Ward.*)

Gas consumption per hour,	3·96 cubic feet.
Ignition pressure,	2· inches.
Illuminating value,	5·49 candles.

Equivalent to 1·38 candles per cubic foot.

Mean of eight (8) experiments, 1·40 candles per cubic foot.

TABLE SHOWING RECORD OF PHOTOMETRIC TESTS OF THE LOWE INCANDESCENT LIGHTS.—GAS USED, LOWE WATER-GAS.

No. of Experiments.	*Gas Consumed in Cubic Feet per Hour.*	*Pressure at Burner, Inches.*	*Candle-Power.*	*Candles per Cubic Foot.*
1	9·69	2·25	12·85	1·33
2	8·31	2·37	10·88	1·31
3	7·91	2·5	12·24	1·55
4	6·7	1·75	8·48	1·26
5	6·7	1·	8·41	1·25
6	5·58	3·25	9·94	1·78
7	5·1	1·5	6·85	1·34
8	3·96	2·	5·49	1·38
Mean of eight (8) experiments,				

From the results of these tests an approximate estimate of the cost of this light, as compared with ordinary illuminating gas, *light for light*, may be made as follows:

If we assume the cost (to consumers) of coal-gas of seventeen candle-power (equal to 3·4 candles per cubic foot) to be $1.50 per 1,000, the cost of water-gas must not exceed sixty-one and three-fourths cents per 1,000. If we assume coal-gas of seventeen candle-power to cost the consumer $1 per 1,000, the cost of water-gas must not exceed forty-one and one-sixth cents per 1,000; or, in round numbers, sixty and forty cents, respectively.

In other words, to compete on equal terms with ordinary illuminating gas, the Lowe incandescent light will have to be supplied at two-fifths the cost of the former.

Whether such economy can be obtained, depends to a large extent upon the cost of distributing the gas, which will depend largely, in turn, upon the amount of consumption for fuel and lighting purposes; so that any estimate based upon the cost of gas in the holder, will be very misleading. On the question of economy, therefore, the judges refrain from expressing an opinion.

The judges availed themselves of the opportunity afforded them after the close of the Exhibition, to make a second series of photometric measurements of the Lowe incandescent burners, with the object of verifying and controlling the results of their first set of observations. The results are given below, and show a satisfactory uniformity between the two sets of observations.

PHOTOMETRIC RECORD.—(Second Series.)

(*1.—Observers: Greene, Marks and Wahl.*)

Gas consumption per hour,	7·8 cubic feet.
Ignition pressure,	2·3 inches.
Illuminating value,	10·6 candles.

Equivalent to 1·36 candles per cubic foot.

(*2.—Observers: Greene, Marks and Wahl.*)

Gas consumption per hour,	9·9 cubic feet.
Ignition pressure,	2·1 inches.
Illuminating value,	12·83 candles.

Equivalent to 1·29 candles per cubic foot.

(*3.—Observers: Greene, Marks and Wahl.*)

Gas consumption per hour,	4·74 cubic feet.
Ignition pressure,	2·75 inches.
Illuminating value,	6·85 candles.

Equivalent to 1·45 candles per cubic foot.

Mean of three experiments, 1·37 candles per cubic foot.

TABLE SHOWING RECORD OF PHOTOMETRIC TESTS OF LOWE INCANDESCENT BURNERS.—GAS USED, LOWE WATER-GAS.

No. of Experiments. (2d Series.)	*Gas Consumed in Cubic Feet, per Hour.*	*Pressure at Burners, Inches.*	*Candle-Power.*	*Candles per Cubic Foot.*
1	7·8	2·3	10·6	1·36
2	9·9	2·1	12·83	1·29
3	4·74	2·75	6·85	1·45
Mean of three experiments,				*1·37*

The judges make the following recommendation: To the Lowe Manufacturing Company, Norristown, Pa., for substantial improvements in the manufacture of water-gas, and in appliances for using water-gas for fuel; for ingenuity displayed in methods for using water-gas for illuminating purposes, and for general excellence of collective exhibit of the capabilities of water-gas—

A SILVER MEDAL with a reference to the Committee on Science and the Arts, for such higher award as it may deem proper to make.

DESTRUCTION OF TROUT BY MOSQUITOES.—A recent *Bulletin* of the United States Fish Commission contains the following interesting account: "In the middle or latter part of June, 1882, I was prospecting on the headwaters of the Tumichie Creek, in the Gunnison Valley, Colorado. About 9 o'clock in the morning, I sat down in the shade of some willows that skirted a clear but shallow place in the creek. In a quiet part of the water, where their movements were readily discernable, were some fresh-hatched brook or mountain trout, and circling about over the water was a small swarm of mosquitoes. The trout were very young, still having the pellucid sack puffing out from the region of the gills, with the rest of the body almost transparent when they swam into water lighted up by direct sunshine. Every few minutes these baby trout, perhaps to get the benefit of more air, would come up, so that the top of the head was level with the surface of the water. A mosquito would then light down and immediately transfix the trout by inserting its proboscis, or bill, into the brain of the fish, which seemed incapable of escaping. The mosquito would hold its victim steady until it had extracted all the life juices, and when this was accomplished, and it would fly away, the dead trout would turn over on its back and float down the stream. I was so interested in this before unheard-of destruction of fish that I watched the mosquitoes for more than half an hour, and in that time over twenty trout were sucked dry and their lifeless bodies sent floating away with the current. I have been unable by inquiry to ascertain if others have observed a similar destruction of fish. I am sure the fish were trout, as the locality was quite near the snow line, and the water was very cold, and no other fish were in the stream at that altitude. From this observation I am satisfied that great numbers of trout, and perhaps infant fish of other varieties in clear waters, must come to their death in this way; and if the fact has not been heretofore recorded it is important to those interested in fish-culture." C.

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